VOLUME XLVI NUMBER 4 WHOLE 402

SCHOOL SCIENCE AND MATHEMATICS

APRIL 1946

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

All matter for publication, including books for review, should be addressed to the editor. Payments and all matter relating to subscriptions, change of address, etc. should be sent to the business manager.

Entered as second class matter December 8, 1932, at Menasha, Wisconsin, under the Act of March 3, 1879. Published Monthly except July, August and September at 450 Ahnaip St., Menasha, Wis

PRICE. Two Dollars and Fifty Cents a year; foreign countries $3.00; current single copies 35 cents

Contents of previous issues may be found in the Educational Index to Periodicals.

Copyright 1946, by the Central Association of Science and Mathematics Teachers, Inc.

GLEN W. WARNER
Editor
7633 Calumet Ave., Chicago 19

RAY C. SOLIDAY
Business Manager
Box 408, Oak Park, Ill.

DEPARTMENTAL EDITORS

BOTANY—A. G. Zander
Boys' Technical High School, Milwaukee, Wis.

CHEMISTRY—E. G. Marshall
LaSalle-Peru-Oglesby High School and Junior College, LaSalle, Ill.

CHEMISTRY RESEARCH—B. S. Hopkins
The University of Illinois, Urabana, Ill.

ELEMENTARY SCIENCE—David W. Russell
The Avery Coonley School, Downers Grove, Ill.

GENERAL BIOLOGY—John E. Potzger
Butler University, Indianapolis, Ind.

GENERAL SCIENCE—Walter A. Thurber
State Teachers College, Cortland, N.Y.

GEOGRAPHY—Villa B. Smith
John Hay High School, Celeveland, Ohio

MATHEMATICS—George E. Hawkins
Lyons Twp. High School and Junior College, LaGrange, Ill.
H. C. Christofferson
Miami University, Oxford, Ohio

MATHEMATICS PROBLEMS—G. H. Jamison
State Teachers College, Kirksville, Mo.

NATURE STUDY—E. Laurence Palmer
Cornell University, Ithaca, N.Y., and the American Nature Association

PHYSICS—Homer W. LeSourd
39 Kirkland St., Cambridge, Mass.

PHYSICS RESEARCH—Joseph D. Elder
Wabash College, Crawfordsville, Ind.

SCIENCE DEMONSTATIONS—Wm. A. Porter
The University High School, Madison, Wis.

ZOOLOGY—Howard E. Wright
Shortridge High School, Indianapolis, Ind.

Turtox Biology Booklets

The following illustrated booklets are now available:

Bacteriology Booklet, 1946 Edition.

Living Specimens in the School Laboratory.

The Collection and Preservation of Animal Forms.

Laboratory Experiments in Nutrition.

Microscopy Booklet, 1946 Edition.

These booklets are priced at $1.00 per copy, postpaid.

GENERAL BIOLOGICAL SUPPLY HOUSE
Incorporated
761-763 EAST SIXTY-NINTH PLACE
CHICAGO 37, ILLINOIS
The Sign of the Turtox Pledges Absolute Satisfaction

Through mathematics we give children a language, not an ordinary language like Greek or Latin or English that may perish, but an everlasting language of quantity, a universal language through whose medium rare secrets can be discovered, a service language whose phrases, sentences and implications can be found in nearly all aspects of life.—H. C. CHRISTOFFERSON.

CONTENTS FOR APRIL, 1946

Central Association of Science and Mathematics Teachers—*Arthur O. Baker, President* 297

The Place of Cooperative Education in a Peacetime Program—*Ovid W. Eshbach* 299

A Water Pressure Demonstration—*Homer W. Le Sourd* 304

The Contribution of the Film in Inducting the Young Citizen into the World of Science and Technology—*V. C. Arnspiger* 305

The Quiz Section—*Julius Sumner Miller* 311

An Apparatus Catalog as a Time Saver—*Rebecca Andrews* 312

The Use of Mathematics in the Beautification of School and Home Grounds—*Merton T. Goodrich* 313

The Practical Value of Certain Topics in a Course in Biology—*John W. Schneck* 318

Computations in Precision Riveting—*Ronald L. Ives* 323

History of Arithmetic, II—*Walter H. Carnahan* 329

A Universal Subject—Geography—for the Secondary School—*Minnie E. Lemaire* 335

Some Mathematics of the Honey Comb—*R. F. Graesser* 339

Cost Factors in Science Teaching—*Traver C. Sutton* 344

The Inverse Distributive Law—*A. R. Jerbert* 351

Aviation Geography in the Oak Park High School—*Helen S. Turner* 358

Rationality and Emotionalism—*John Benjamin Nichols* 365

Notes from a Mathematics Classroom—*Joseph A. Nyberg* 372

Eastern Association of Physics Teachers. One Hundred Sixtieth Meeting—*Carl W. Staples* 376

Address: New Goals in School Health Programs—*Curtis M. Hilliard* 377

Address: Textile Research Looks Ahead—*Edward R. Schwarz* 378

Address: War-Surplus Electronics Equipment—*L. B. Arguimbau* 380

Problem Department—*G. H. Jamison* 385

Books and Pamphlets Received 391

Book Reviews 392

WE COVER THE EARTH

School Science and Mathematics

is read by subscribers in every state of the Union, all provinces of Canada, and thirty-three foreign countries.

It is owned by teachers, managed by teachers, and edited by teachers.

It comes to your desk every school month.

Interesting Articles in Volume 45

Power for War—Arches through the Ages—Adapting Instruction in Science and Mathematics to Post War Conditions and Needs—Aircraft Instrumentation—The Chemist in the Petroleum Industry—Those Drugs of Ours—Trends, Deficiencies, and Challenges Related to General Science—Indian Medicine—Our Warty Assistants—A Historian Views Science—What Is Going to Become of High School Mathematics—Earth Science in High School—Science, Mathematics, Industry—Guayule: an American Source of Rubber—Solid Reactions—Measurement of Forest Fire Danger—Mastery of the Fundamentals of High School Mathematics: a Graduation Requirement—Conics Are Fun—The Modern Aircraft Propeller and the Physics Course—Pets in the Kindergarten.

Helpful Reprints and Supplements

An Objective Test in Logarithms	$.10
Mock Trial of B versus A—A play for the Mathematics Club	.30
100 Topics in Mathematics—for Programs or Recreation	.25
Poison War Gases	.20
Popular Mathematics: Bibliography	.10
Fractional, Zero and Negative Exponents—A Unit in Algebra	.20
Teaching Mathematics: New Materials and Equipment	.15
The Radical Dream—A Mathematical Play for Puppets	.15
Geometry Theorems: A List of Fundamentals	.15
How Water Serves Man. A teaching unit	.20
Point College—A mathematical farce	.20
Biology Reading List	.10
Won by a Nose. A chemistry play	.25
Kem: Two Games for Chemistry Classes	.15
Modern Periodic Arrangements of the Elements; illustrated	.25
Ion Visits the Realm of Air. A Play	.25
The King of Plants. A play for science clubs	.25
Teaching Living Biology	.20
Three Families of Great Scientists: dramatized	.15
Some Lessons About Bees. A 32-page booklet; illustrated	.20
The Triumph of Science. A play for auditorium programs	.25
In a Sound Studio. A play: Physics and Music	.25
Safety First. A Unit in Eighth Grade General Science	.20
Science Library. Recent books for high schools	.10
Youth Looks at Cancer. A biology play	.25
Laboratory Work in Single Periods: Method	.15
Modern Science Teaching Methods: Demonstrations	.25
Science in the Grades: Practical Contributions—35 pp.	.30
An English Christmas Tree—A Conservation Play	.25
Extracting Aluminum. A one act chemistry play	.15
Vitalizing Chemistry Teaching. A Unit on the Halogens	.15
Telescope Making Illustrated	.25
A Scientific Assembly Program, Wonders of Science	.30
The History of Arithmetic—200 pages; illustrated	1.50
Elementary School Science Library	.10
Projection Demonstrations in General Science	.20

Orders for Reprints must be prepaid.

SCHOOL SCIENCE AND MATHEMATICS

Price $2.50—Foreign $3.00.

No numbers published for July, August and September

P.O. Box 408, Oak Park, Ill.

SCHOOL SCIENCE AND MATHEMATICS

VOL. XLVI APRIL, 1946 WHOLE NO. 402

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

DEAR FELLOW MEMBERS:

As one grows older in the field of education he may find his interests and obligations in educational organizations expanding. The beginning teacher may join very few such organizations. However, as one's educational horizon broadens he may take advantage of the numerous opportunities to join and participate in the many constructive educational organizations that exist in this country. After attending meetings, reading magazines, and working with fellow members in such organizations, a teacher cannot help but arrive at certain mental appraisals of the contributions of each.

High in my memory of the work of educational organizations will stand the recollection of experiences in the Central Association of Science and Mathematics Teachers. About twenty years ago my attention was first directed to this group. After joining the Association and examining the yearbook and the magazine, SCHOOL SCIENCE AND MATHEMATICS, I was impressed immediately with the contributions which this organization could make and was making to science and mathematics teaching. Intermittently, I began attending conventions. Always I came away inspired and impressed with the fact that this was an organization which was able to get down to the practical aspects of teaching and do something about them.

My interest and activities continued to grow, and during the past eleven years regular attendance at the conventions and participation in the affairs of the organization have brought rich dividends in educational experiences. Again and again the

point has been impressed upon me that this organization really gets down to earth and emphasizes practical procedures for classroom use.

Each year it is becoming an increasing pleasure to renew my faith in the Central Association! Each year I look forward to meeting again the many friends that I have made over the years at the annual convention! Each year I get more help and inspiration from SCHOOL SCIENCE AND MATHEMATICS!

If you are a previous member in the Association and have not renewed your membership, let me invite you to renew your faith in the Central Association. If you are contemplating joining this organization for the first time, let me welcome you into our group and invite you to participate in experiences which you will cherish and remember well as the years roll by.

To all members let me extend the hope that I shall see you at the 1946 convention in Detroit when we will again consider how science and mathematics teaching can be oriented to the tasks that lie ahead!

Very truly yours,
ARTHUR O. BAKER, *President*
Central Association of Science
and Mathematics Teachers

EDNA C. BATTIN

Edna C. Battin, Association member since 1940, died in the early part of this school year. She was a teacher of mathematics in the Union High School at Colton, California, and had been a regular subscriber and reader of this journal since 1923.

THE NATIONAL CHEMICAL EXPOSITION

The date of the National Chemical Exposition has been moved up to September 10th to the 14th inclusive in 1946 and will be held at the Chicago Coliseum at 15th and Wabash Avenue, says Dr. H. E. Robinson, Assistant Chief Chemist of Swift & Company, and chairman of the Exposition Committee of the Chicago Section of the American Chemical Society—sponsor of this well established international event. Marcus W. Hinson, who has managed these expositions since their inception in 1940, will again be Exposition Manager.

The registration of over 21,000 at the last exposition is very likely to be greatly exceeded, says Dr. Robinson, as industrial managers, chemists and engineers are very anxious to see how war time developments are going to affect post war products and production.

THE PLACE OF COOPERATIVE EDUCATION IN A PEACETIME PROGRAM*

OVID W. ESHBACH
The Technological Institute, Northwestern University, Evanston, Illinois

"Experimenta Docet" is an old Latin motto and truth which has been accepted as an axiom. The teaching function of experience is the heart of the cooperative idea, just as science and technology characterize engineering education.

Paraphrasing Herbert Spencer's statement, "Only when genius is married to science can the highest results be produced," we can say only when education is married to American culture can the highest results be produced. Industry and commerce characterize much of American culture.

Both of the terms experience and teaching have broad connotations. No two human experiences are alike in the sense that the same observations and reactions result. History is a record of past experience, much of which lacks the stimulating force of a personal witness. It is valuable in establishing a social perspective, and when studied in correlation with social science, has predictive value for future prophecy and action. Physical science differs largely in being more specific, more capable of reproduction, study and formulation, but it is still a record of experience. Technology is the application of science to special commercial objectives, relatively easy to formulate and repetitive in character. Mechanics of materials and construction practices, the science of electricity and the transmission of power and intelligence, organic chemistry and petroleum production, the science of heat and thermodynamic application, and fluid mechanics and aerodynamic design are typical examples of relations between science and technology.

Now that the war is over, veterans are returning, and restrictions due to military draft are about to change, many will be considering the merits of cooperative education.

When properly done there is no better or more effective method of education, particularly for professional vocations. I hesitate to broaden this statement to include other occupations, especially those requiring little formal education. Nor do I believe that cooperation with American industry and commerce can be very effective for those who have no definite convictions

* An address to the Junior College Group of the Central Association of Science and Mathematics Teachers, November 24, 1945.

as to their life work, or are pursuing programs of purely general or liberal education.

In the early development of cooperative education there was the ideal of stimulating the transmission from science to technology by work experience. For obvious practical reasons a time correlation cannot be planned. If it were possible—and sometimes it occurs—it would be an ideal way of developing engineers.

It becomes practically impossible to plan sequences of experiences for situations where the objective is not defined or the work atmosphere is only remotely related to future occupational activity. One principle which may not be violated, if programs are to be continuously and enthusiastically supported, is, as a salesman would put it, "looking for the customer benefits." The customer is the firm doing the employing.

I do not mean to deny the value of experience in general education, but the attempt to formalize it—not impossible but most difficult—cannot easily proceed under cooperative agreements and might well defeat the purposes for which it was intended.

A good procedure for every liberal arts college would be to require one year of work experience as a condition for admission.

All education has the general objectives of imparting knowledge and developing power or skill in performing the many and diversified social tasks which our complicated society requires. Cultural objectives go beyond the effective performance of these tasks and aim at the achievement of the most ideal human relations. A well-balanced education embraces knowledge, skill, and culture. In a broad sense, degree of emphasis and definiteness of objective are the only things which differentiate trade, professional, and general education. To assume that any or all of them must be acquired through formal institutions is to deny the educational value of experience.

Frequently cooperative education has been attempted as a solution to vocational guidance. As such it is not ideal, nor have any other attempts been particularly promising in this field.

It is most effective, however, when occupational or professional preference has been determined and experience can be planned with mutual benefits to employer and student. Through these channels men will mature more rapidly and be stimulated to much higher levels of achievement and appreciation.

Engineering is a form of professional education. Its group is defined particularly by special knowledge common to all and

the character of skill acquired. As in other professions, individual success depends upon ability to cope with a multitude of diversified problems which arise continually and require rapid and accurate solution. Thus its value is not to be measured alone by the quantity of information acquired but also by the flexibility and versatility with which it develops. The vital requisite is a disciplined mind, with the perspective, the judgment, and the ingenuity necessary to derive the greatest possible value from the information available. This is so generally characteristic that unconsciously the term "engineering" is popularly applied to many acts which require skillful planning and execution, even though they are unrelated to science and technology. In fact, the generic meaning of the word is derived from the Greek meaning *ingenious*. It is only by a trick of etymology that it has become associated with engines. Consequently, it is of great importance, at the beginning when the foundations of science and mathematics are taught, that strenuous efforts be devoted to creating the facility for clear, logical, and rapid thinking. The discipline and habit-forming functions of regular employment in industry contribute at an early age to the subsequent accumulation of factual knowledge and the cumulative development of an alert and well-conditioned mind, independent of the kind of experience to which students are subjected.

Thus cooperative education achieves the objective of a powerfully effective program of training in the most direct and comprehensive way. The student looks at the field of engineering not only from the narrow viewpoint of the technologist who devises machines and methods, but also from the practical viewpoint of the doer who translates them into action. This combination of theoretical training and experience invites and encourages a correlation which may not otherwise be possible or expedient, and which contributes considerably to the value derived from each. With principles of science fresh in mind, the student takes his place in industrial activity, where the value of particular knowledge and a broad understanding of numerous apparently unrelated fields is impressed upon him. His period in industry completed, he returns to college and finds that his academic work assumes a new and interesting significance.

While in its broader philosophic aspects this characterizes the dynamic contribution of early work experience, it is by no means limited to this significance. Engineering is segregated into divisions. They are a heritage of experience, maintained by tradi-

tion and vested interest, both professionally and educationally rather than industrially. These divisions are differentiated from one another by selected fields of technology.

So long as our present provision for professional specialization exists, cooperative education will be expected to enhance technical knowledge in traditional courses. While it is not an absolute essential that civil, electrical, mechanical, and chemical engineers' work experience be in their chosen field, it is desirable, and aside from the knowledge acquired, contributes to the morale of students who have prematurely fixed their attention on specialized fields.

Much of experience is haphazard and opportunistic in character, and the most loosely organized experience can hardly fail to contribute both to professional maturity and breadth of knowledge. On the other hand, improvisation is a very doubtful way of action.

What is the best plan to insure the maximum contribution of work experience to the scientific and technological stem of engineering education? I hold the opinion that successful cooperative education does not depend upon any one plan. The common divisor of all plans is a philosophy rather than a method. It assumes the inseparability of technical education and industrial activity.

But, if conditions would permit free choice of method, I should incorporate these essentials in a well-organized plan:

1. I would select only those students who showed promise of scholastic success and later professional achievement.

2. To insure the full content of technical instruction of a standard acceptable to the profession, I should choose a five-year plan in which at least the first year would be spent wholly in academic work.

3. I would organize the same courses of instruction for all during the first three years.

4. I would aim during the first half of the students' experience to develop an awareness of the synthesis of technology in industry, habits of study, and would so supervise their placement that the maximum stimulation to learn and work would be achieved in this time.

5. During the last two years of their experience I would make every effort to place students where their experience would contribute most to technological achievement consistent with their desires.

6. I would be fair and considerate in making concessions to industry to insure continued and whole-hearted cooperation.

7. I would arrange the periods of work experience to best meet the wishes of the cooperating industries.

If nothing more were attempted, such a program would command the respect of education and industry. Those who are experienced in the administration of cooperative courses know that this is only a part of the opportunity that is naturally inherent in the plan.

A very important by-product is the enrichment of the technical content of curricula by situations and problems brought back from experience. Wherever seminar courses are organized the standard of papers and educational stimulation is raised to a level unattainable elsewhere. The advantage to the staff is obvious. It not only requires an alertness above the average but adds vitality to the whole program of undergraduate instruction. Stimulation of graduate study and research is a natural sequel.

One of the most frequently overlooked results is the influence of the more advanced students upon the attitude of the underclassmen. Too frequently opportunity for the full play of this influence is denied by overcrowding the curricula. I see little justification for assignments requiring more than the normal engineering schedule even though a higher working efficiency is obtainable. Opportunity for social functions and extracurricular activities in moderation and also free electives in non-technical fields are as important as highly developed specialization for the majority of undergraduates.

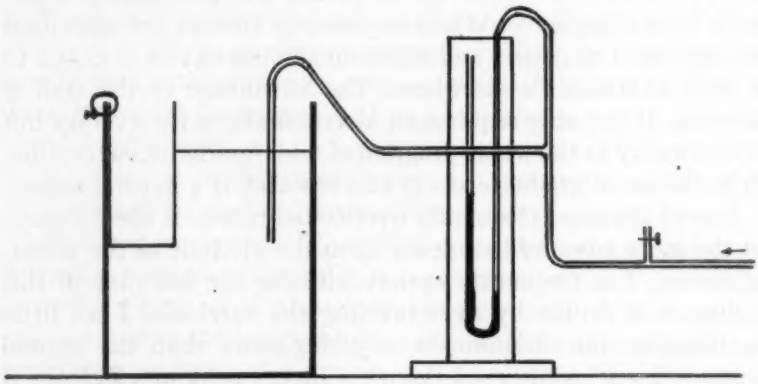
In this discussion I have deliberately chosen to adhere to generalities. The teaching of experience comes in a different way. It comes in bundles of disconnected or isolated events and it would have been characteristic had I chosen a presentation of clinical examples to show some of the influence of work experience both on the development of individuals and its contributions to technical knowledge. These are legion.

"A fearful lot of flubdub is fed to teachers on the mystery of 'living in a democracy.' You'd think it never had been tried, instead of having been the practice of the country for a century and a half. . . . All that living in a democracy requires is that each person shall behave himself, have due regard for the rights and wishes of his neighbor, be willing to give-and-take in matters which require mutual concessions, and render such service as he can for the common good."—*Schenectady Union Star*

A WATER PRESSURE DEMONSTRATION

HOMER W. LE SOURD
Jefferson Physical Laboratory, Harvard College

Various means have been devised for developing the laws of water pressure but they are difficult to manipulate and ill-suited for use in a large recitation room. This demonstration requires compressed air from a motor-driven compressor or from a hand pump and a tank. The accompanying sketch shows the arrangement of apparatus.



First the stop-cock is opened allowing air to escape freely. The nozzle is then lowered to a certain depth in the jar of water and the stop-cock is slowly closed until bubbles of air just emerge from the nozzle. The gauge then indicates the water pressure at the level of the open end of the nozzle. In this manner, gauge readings are made for different depths. Nozzles of bent glass aimed in different directions can also be used. Finally, readings are made with the nozzle at a certain level and again at the same level but just below a liter vessel which is clamped to the side of the jar. The gauge contains water colored with ink and readings can be clearly seen from a considerable distance.

The first cylinder printing press was a failure due to the lack of a satisfactory inking device. Then, as now, the roller was the connecting link between the ink fountain and the form. The glue and glycerine roller was discovered in Engand in 1816 and gave the green light to mechanical printing progress. First American printer to use the new roller was Daniel Fanshaw of New York City, printer for the American Tract and Bible Societies.

THE CONTRIBUTION OF THE FILM IN INDUCTING THE YOUNG CITIZEN INTO THE WORLD OF SCIENCE AND TECHNOLOGY*

V. C. ARNSPIGER

Encyclopaedia Britannica Films Inc., Chicago, Illinois

A member of the research staff recently drew up an outline of the Pygmy curriculum. He did a rather comprehensive job of it and yet its entire contents did not cover a single page. It included such items as:

Learning to talk
Preparing poison for arrows
Finding and climbing honey trees
Throwing hunting spears accurately at moving animals
Hunting and disabling elephants
Building waterproof dwellings with leaves and branches
Making durable and flexible clothing from bark
Becoming acquainted with the mores of his society

By concentration upon this simple curriculum the 12 year old Pygmy is brought to a participating level of citizenship. He is able to take part in virtually all the activities of pygmy life.

Now, let us look at the citizens of our society. Too few can be said to reach a participating level of citizenship within an entire lifetime. So few ever come to realize the true nature of our world of science and technology. Their food is brought together in stores for them—their transportation is furnished by the combined efforts of thousands of men who provide the labor, and other thousands who invest millions so that they can ride. Thousands upon thousands are almost completely ignorant of the vast cooperative enterprise that characterizes modern living. Of course, the major reason for this situation can be found in the ever increasing complexity of modern society, due primarily to an increasing application of technology. This is in turn reflected in the complexity of courses of study in all departments of our curriculum, for example, the science curriculum for four years in one of our cities fills eight large volumes.

The extreme specialization of work and the corresponding specialization of interest combine to take the individual citizen further and further away from any concern with the broader problems of citizenship. In this indifference to public policy—

* Presented to the Central Association of Science and Mathematics Teachers, November 24, 1945.

in this disregard of the problems of labor and industry—in this ignorance concerning international trade—in this lack of intelligent insight into the significance of new inventions, inventions which can and do change the very nature of our existence,—herein lies the seedbed of despotism. The attitude of "let George do it" usually leads to George's doing it and after awhile we wake up to realize that we have another dictator on our hands or another gang leader, or another political boss with the social ethics of the saber-toothed tiger. This certainly is not the democracy we have fought for in two bloody wars involving nearly all the nations on the earth.

What social force can we as a people use in building democracy? There is only one answer—Education. Democracy must by its very nature be built into the hearts and minds of men so that it will permeate the entire fabric of their daily living and human relations. It is not to be imposed from without. It must be accepted by our people because it is more reasonable than despotism. Science teachers must bring citizens not merely to learn specialized details but rather to understand the meaning and significance of science and technology in human affairs. This understanding and the consequent liberation of the human mind from the obsolete ideas of by-gone societies must become part and parcel of every course in our curriculum. If we are to educate our people to live as free men and women we cannot leave this job to the social studies teacher or to the history teacher or to any one kind of teacher. All must bear his share of the load—and what a tremendous load! Today we are going to concentrate upon the field of science instruction.

To begin with, let us say that the science teacher cannot escape responsibility for the social attitude of his pupils. This becomes obvious when we realize that any new scientific discovery or invention may mean a completely new evaluation of the resources of an entire region—for example, the invention of the electrolytic process for the extraction of elemental phosphorous changed a great region in the Tennessee Valley. There the mud of this region, which previously had been used here and there as fertilizer, gave up phosphorous which has been used in the manufacture of literally hundreds of products which have contributed to a higher standard of living for millions of people.

In any field of learning there are two kinds of specialists. First, are those who are concerned only with discreet elements of scientific fact, and, second are those who in addition are con-

cerned with the thoughts and feelings of people and who are thus able to utilize the work of other specialists. These are the people who repudiate the definition of a scientist as a man who knows more and more about less and less. These are the people who are concerned with the whole truth which, as someone has suggested, far transcends isolated scientific events and recognizes the larger context in which they occur.

Any realistic and socially desirable program of science instruction must be built upon this foundation of the whole truth. The statement that "the truth shall make ye free" is one that has come down to us through generations and it is as true now as when it was first uttered. Crooked thinking which often comprehends only part of the whole truth brought disaster to the Japanese people. It has been said that it is hardly possible to see how the Japanese can contribute much that is constructive and genuine to the world of the future so long as their deepest philosophy is rooted in intellectual dishonesty.

Now, if any one group of our teachers can be said to be the guardians of truth more than any other, it is the science teachers. The traditions of this field are rooted in the discovery of truth through understanding the order and magnitude of events. In our pursuit of scientific knowledge let us not ignore the social significance of that knowledge.

One of the most satisfying experiences I ever had as a teacher of biology was the year we studied the common rat as a representative mammal. We learned that he could live upon the same food as man, that he reacted to the deprivation of many of the same vitamins, amino acids and other food elements in a manner similar to that of man. We also learned that he was one of man's deadliest enemies and that his presence cost us millions of dollars each year, that it had been estimated that there were as many rats as there were people in the United States. We also learned by experimentation how to poison him and to trick him into falling for ingeniously constructed traps. We knew his habits, how long he lived, the size of the litter, under what conditions he thrived and grew fat and, in general, his ecological relationships. Yes, we thought we knew all about the rat. But at what we thought was the end of the project a bright youngster raised the question of whether we had enough rats in our town to justify studying them the way we had. This presented a challenge to the other members of the group and we went to work all over again. We estimated from trapped samplings that we

had about 50% more than our share of rats and decided that we should organize our town in a drive against this common enemy. It seemed a simple thing to do. Just tell everybody how to trap rats and set out poisons and to clean up places where rats could live. But to our amazement we found that the citizens of our community did not show our concern with this problem. We learned then what it meant to get people to help themselves. We had to enlist the aid of all avenues of communication available to us—the public press—the platform. Two hundred and fifty speeches were made by 25 members of the biology class. A mass meeting was called by the Mayor and volunteer workers were organized with specific quotas for each subdivision of the town. To make a long story short, in the end we captured and killed 15,000 rats. But more than that, the members of this group learned what it meant to accept their responsibility as citizens. They had learned something of the social implications of scientific phenomena. Not only had they acquired a knowledge of the rat but they had also learned how to make this knowledge functional in their community living. This seems to me to be an important factor in the training of boys and girls to live as free men and women for we must recognize that today it can be said that science more and more furnishes the pattern for social responsibility.

Science teachers can also contribute to habits of mind that are important to a free society; for example, training people in the habit of clarifying objectives, to generalize from available data and to test hypotheses. These, we call aspects of the scientific method.

With the ever-increasing activity of our scientific laboratories, with the opening up of new areas of research, for example in the field of nuclear physics, we must come to realize that all our tools of instruction must be used if we are to equip our young citizens to participate effectively in the new world of science and technology. Let us see what these tools are. They each represent a great adventure in communication. First was the invention of the spoken word. Thousands of years rolled by in laborious succession before man mastered a system of speech which made possible the transmission of the more abstract ideas from one mind to another. Second, there is the printed word. With the invention of printing man first began to break the bonds of ignorance on a grand scale and to move en masse toward the frontiers of knowledge.

But science teachers, ever alert to the need for actual experience in the instructional process, invented the laboratory demonstration as a tool to make real and understandable the scientific invariants discovered by the world's great scientists. This marked a great step forward in teaching method and was copied widely in many other types of teaching situations. Then from various parts of the world came the basic inventions which made possible the motion picture, described by President Hopkins of Dartmouth as "the first qualitative contribution to communication since the invention of printng." Here we had a medium which made available for instruction all the facilities of the language and graphic arts. We came to realize that through the film we could clarify and interpret scientific phenomena which for a large part of our population would otherwise remain obscured in the mists of abstraction. We found that we no longer needed to depend exclusively upon verbal and written symbols for communication. The scientific film provides selected experiences focussed upon the meaningful concepts underlying any situation. We were forced to realize upon contrasting this type of learning with the usual stereotyped "experiments" prescribed for laboratory work that instead of being too often an end in itself, the scientific film provided stimulation to continued exploratory thinking. We came to realize that the saving of time in learning through the use of film came because this medium was so effective in presenting the significant elements out of which concepts could grow. We saw children, studying films in the first grade before they learned to read, master many of the biological concepts which had traditionally been withheld until years later at the secondary level. We found that many limitations to learning inherent in traditional mediums of communication disappeared when the facilities of film language were brought to bear upon the problem.

The first films designed for fundamental science instruction were used by some of the nation's foremost science teachers. Outstanding scientists hailed the new medium as a tool with possibilities that challenged the imagination of our best minds. Dr. Millikan of the California Institute of Technology said of a film on sound that, "It gives in a few moments' time a thoroughly correct presentation of the mechanism of so-called sound condensations and rarefactions."

From teachers out on the front line of education, many of whom are seated in this audience, we learned the simple pro-

cedures which should govern the use of the film in the classroom —that before any film is shown in the classroom every pupil should know the specific purposes for studying the film, that the showing should follow immediately the establishment of these purposes and that ample time should be given to a carefully planned discussion following the film showing so as to use this powerful medium as a springboard into a rich variety of further individual learning experiences.

We realized that the most important responsibility of the film producer, like that of the science teacher, was to tell the truth and the whole truth which can be done so effectively through the film with its use of sight and sound. Obviously each film should carry the weight of authority which could be assured only when produced in collaboration with the nation's outstanding scientists. These men were sought out wherever they were to be found and their contribution to the development of this medium has been monumental. The film is highly effective in its capacity for integrating specialized knowledge and synthesizing discrete facts into operating concepts revealing their social significance so necessary to good citizenship. The resources of many of the nation's greatest laboratories are thus made available through the film to the schools as widely separated as the Union of South Africa, New Zealand, Australia and China.

With the coming of war our technology had made possible the production of guns, tanks, planes and all the other tools of combat by the millions. Our mass production led the world. But when we came to train men to use these implements of war we realized that they had to be trained one by one, that we had actually made little progress in mass military instruction since the days of Washington. Then at the continued insistence of classroom teachers and others who had learned the effectiveness of the film in instruction in our schools before the war, this medium was used in thousands of training situations—more training films were produced within a few years than ever before. It would be an old story to tell again of the tremendous saving of time and of the great increase of effectiveness of our armed forces which could be traced directly to the training film. Here in the crucible of war, when our very existence depended upon rapid, effective training, the instructional film came into its own. From this experience and from the experience of teachers all over the land, we have come to realize that for the first time

in the history of man we have in the film, a medium of communication which makes possible the education of citizens of the State, the Nation, the Super region and the World, on a level as effective as that of the Pygmy living a simple life where all training is functional and all education tied in with actual experience.

There is today opening before us vistas of a new world of science and technology. We must assume responsibility for equipping our people to live in this world on a high level of effectiveness. This process demands the exercise of all our ingenuity and creative ability. To meet these greater tasks of peace we can do no less than we did in war. Indeed we must do as much and more than we did for war. This does not demand that the science teacher become a sociologist but that he use every possible means to give students the understanding and concepts which each must have to live as a free man in the modern world of science and technology.

THE QUIZ SECTION

JULIUS SUMNER MILLER
Chapman College, Los Angeles 27, California

1. When and by whom published was the theory that the population of the world would soon outrun its food supply?
2. Among the hydrocarbons the boiling points of the liquids rise with increase in the number of atoms in the molecule. Accordingly, kerosene boils at a higher temperature than gasoline. (T or F.)
3. An approximation to the age of the earth is gotten by determining the total amount of salt in the oceans, by sampling. (T or F).
4. Arrange in proper sequence: eggs, larva, pupa, adult.
5. To an observer on the moon the sun would always appear white and the sky black. (T or F).
6. Spring is the period from the vernal equinox to the summer solstice. (T or F.)
7. A man undertakes to complete a job in 17 days and puts 15 men on it. After 7 days he finds that only one-third of the work has been done. How many more men will be needed to do the job in time?
8. A determinant is a symbol for a polynomial. (T or F)
9. The number of real roots of an equation with real coefficients *may be less* than the degree of the equation. (T or F).
10. In a camera, an aperture of $f/8$ would call for $\frac{1}{4}$ of the exposure time needed by f/16. (T or F)

ANSWERS TO THE QUIZ SECTION

1. Malthus 1798; 2. T; 3. T; 4. Correct as stands; 5. T; 6. T; 7. 6 men; 8. T; 9. T; 10. T.

AN APPARATUS CATALOG AS A TIME SAVER

REBECCA ANDREWS
Eastern High School, Washington, District of Columbia

In these days of teaching physics with a lengthy course of study to be completed and little time in which to complete it, a free exchange of ideas for improving the efficiency of setting up demonstrations and laboratory experiments might be helpful. There is presented here a method of cataloging demonstrations and experiments that has proved to be effective.

All demonstrations and laboratory experiments are catalogued on 3×5-in. cards according to the order in which they are to be set up for use during the year. The cards are placed in two 3×5-in. file boxes, one for demonstrations and one for laboratory experiments. Each card for a demonstration has on one side (1) a labeled drawing of the apparatus as it looks when set up, and (2) the page number of the textbook which is used as the source of the demonstration; and on the reverse side (1) a complete list of the apparatus required, (2) the location of the apparatus in the laboratory, and (3) special suggestions, if any, concerning the set-up. Each card for a laboratory experiment has (1) a complete list of the apparatus used, (2) the location of the apparatus in the laboratory, (3) the number of pieces of each kind needed for a class of thirty students working as partners, and (4) special suggestions, if any, concerning the set-up.

In a high school one teacher usually teaches two or more physics courses at one time. If high standards are maintained, it is quite possible that he sets up during a period of one week an average of nine demonstrations and sufficient laboratory apparatus for a class of 30 students working as partners. The method described has been found to facilitate matters in such a situation. The original expenditure of time used in making the cards is more than compensated by the time saved later in setting up demonstrations and laboratory apparatus.

23,870 EXPRESS SHIPMENTS EVERY HOUR

The Railway Express Agency handled more than 209 million shipments in 1945, averaging some 572,800 express shipments per day for the 365 day period, or an average of 397 shipments every minute of the year—or 6.6 shipments every second!

THE USE OF MATHEMATICS IN THE BEAUTIFICATION OF SCHOOL AND HOME GROUNDS

MERTON T. GOODRICH
Keene, Teachers College, Keene, New Hampshire

It is well known that beautification of environment makes living more enjoyable. A teacher will have accomplished something worth while if she, by a school project, can inspire her pupils to improve their school grounds and appreciate these improvements. Even greater will be her success if her pupils become so enthusiastic over what they have done that they carry the idea home; with the result that their parents improve the home surroundings, or give permission to the pupils to go ahead and make their own dooryards more attractive. A project for the improvement of school grounds may become an incentive for the improvement of home grounds. The subject of mathematics, if properly taught and applied, is fundamental to this project.

At Keene Teachers College, President Lloyd P. Young has encouraged the use of projects of this kind in the training of teachers so that they may make their schools of real and appreciated value in their communities. Every member of the faculty is working with the students on some project, or group of projects, which will promote the enrichment of living by education. All of these projects are under the supervision of Dr. Lloyd P. Young and the Coordinator, Maynard C. Waltz.

The classes in biology and nature study of Keene Teachers College have as one of their long time projects the improvement of home grounds, school grounds, and roadsides. In the spring semester of 1944–45, as a part of this project, they were engaged in the origination and development of ideas for the beautification of the College Campus and the grounds of the Wheelock Practice School. The mathematics classes cooperated in this work by surveying the campus and the school grounds and making a detailed plan of the campus. In the fall semester of 1945–46 the work will be continued. This project is spread over more than one semester for three reasons, (1) in order to devote a fair proportion of time to this unit among all the units of the mathematics courses, (2) so that no student will devote too

much time to any one activity, (3) and to provide participation for as many students as possible.

The procedure is as follows. First, the mathematics students make very careful measurements of the buildings, fences, and walks on the premises, working in small groups and with different members of the class checking on each other's work. Similarly, several working plans are drawn to scale. Upon these plans, the students in biology and nature study indicate the exact location of important trees, shrubs, hedges, and perennials and plot in their original suggestions for the improvement of the grounds.

One of the most important features of a project of this kind in a teachers college is to carry it on in such a way that prospective teachers will be able to use it. They must see how it can be done in a simple, inexpensive manner, so that when they go out into a small school where costly apparatus is not available, they will know those methods which are feasible in such a school. In surveying the college campus, therefore, the use of a transit was avoided. The students learned by experience how measurements can be made very accurately by means of a tape only.

They also learned that mathematics may be taught in such a way as to foster habits of accuracy in action and in thought. They saw that an elementary mathematical law such as, "two lines intersect in only one point," makes possible the location of a point on the school grounds. They did not merely read this in a book. They made it a part of their experience by measuring two intersecting lines from two known points with a tape.

The student teachers, after graduation from college, with this and many other similar facts and methods in mind, will be able to carry these ideas to their pupils. The boys and girls may take the practical results home. The parents may not only have a greater appreciation of the values of mathematics and the importance of the school, but seeing and hearing about the improvements on the school grounds may be an incentive for them to improve their own surroundings. Then the school will be functioning for the enrichment of the community which supports it.

Of course another matter that teachers must bear in mind is the adaptation of a project to the level of the pupils. All of the mathematics students engaged in this project are in the Secondary Course and hence are planning to teach in Senior or Junior High Schools. The mathematics involved in this project is not

too difficult for pupils in the seventh or higher grades. In fact, such a project as this furnishes just the motivation needed for the study of points, lines, angles, triangles, rectangles, radii, arcs, for the meaning of parallel and perpendicular, and for the study of proportion, certain fractions, and denominate numbers.

No trigonometric ratios are necessary in this project. To make a survey using trigonometric ratios when they are not needed, and telling the pupils that the survey illustrates the use of trigonometry, fools nobody least of all the pupils. Trigonometry has its uses in measuring inaccessible distances and angles, and plenty of real illustrations may be found for its use. But this project illustrates not the use of trigonometry, but the real values and uses of arithmetic and geometry. The procedures followed in some of the most interesting parts of the survey show just how arithmetic and geometry were used.

When a building or walk is longer than the tape (or yardstick) that is used to measure it, more than one placement of the tape (or yardstick) must be made, and the total length is the sum of these placements or measurements. This illustrates the situation where the whole is the sum of its parts, and sometimes requires the addition of the denominate numbers, feet and inches.

While the students are out of doors making the survey, they draw a rough sketch showing all the points and all the lines that are measured, labeling each line with its length in feet and inches, but making no attempt to construct the sketch to scale, trying only to have it represent approximately the position and dimensions of the objects.

The importance of using an accessible straight line as a base is emphasized. The side of a building along the foundation or the edge of a walk is good for this purpose. In fact one end of such a line must be the starting point for the survey. Several points on this base line are exactly located and marked with chalk. Establishing these points one after the other illustrates the extension of a straight line. Records are made of the distances between these points. This again illustrates the whole as the sum of its parts.

From these definitely located points, lines are measured which locate another point. A third line is drawn to this point merely as a check. If the measurements are correct, the third line will pass through the intersection of the first two. The results are satisfactory if the third line passes very close to the intersec-

tion. As soon as the new point is definitely located, it in turn may be used as the starting point for a new measurement. In this way the whole campus may be covered without the use of a transit.

The theorem that lines perpendicular to the same straight line are parallel is used when locating a walk that runs along the side of a building, and in checking the shape of a building whose corners have been located as above described.

To determine whether a corner of the grounds is a right angle, measurements of thirty feet and forty feet may be made along the sides of the angle away from the corner or vertex. If a line cutting across between the ends of these measurements is fifty feet long, the angle is a right angle. If something is in the way so that distances as long as these cannot be measured, other distances in the same ratio such as twelve, sixteen, and twenty feet, give the same check. This is a case of the use of the hypotenuse law, the use of ratio, and a demonstration of the procedures of the Egyptian rope stretchers.

Another theorem used is that corresponding sides of similar figures are proportional. If this were not a mathematical law, making a scale drawing would be impossible. When the scale drawing is begun a convenient scale must be decided upon. This scale is an arithmetical ratio. All measurements must be reduced by this scale. It was found to be a great saving of time to make a table showing the fractional parts of an inch corresponding to short distances on the ground. This procedure makes use of the processes of division, addition of fractions, and of denominate numbers, and shows the fundamental principles of making a mathematical table.

Two different types of scale drawings may be made. The first is the working drawing, which is made with pencil, and is the practical one to use to portray and develop ideas for alterations or additions to the grounds. Students were given practice in making this type because it is the one they will need in the future in their own schools. It is just as accurate as the more elaborate drawing, it has just as much educational value, and it does not absorb time which the high school teacher needs for other duties.

The second type of scale drawing is needed only to show people outside of class what is being done or what is proposed. This plan is a tracing of the working drawing and is done in ink.

Conclusion

The activities of this project may be listed from an educational standpoint. The aim is the enrichment of living through the beautification of environment.

The objectives are for the students to acquire:

(1) more complete understandings of the fundamental processes of arithmetic

(2) understandings of the processes involved in finding ratio, in solving proportion, in adding fractions and denominate numbers

(3) understandings of a few geometrical laws relating to triangles, parallel lines, corresponding sides of similar figures, and the hypotenuse law

(4) concepts of simple geometrical figures

(5) skills in measurement, taking field notes, computation, and drawing plans to scale

(6) appreciation of the need for accuracy in these skills

(7) habits of accuracy and carefulness

(8) appreciation of the beauty of well arranged and well kept grounds, and of the benefits of pleasant surroundings

(9) appreciation of some of the true values of mathematics

(10) knowledge of a set of procedures by which they, when teaching in the future, may make mathematics a vital subject, a series of thrilling activities, a means of making life more worth while.

QUANTITY PRODUCTION OF HEAVY-WEIGHT CARBON TO AID MEDICAL RESEARCH

For use in research on cancer, diabetes, arterial, heart and other diseases, carbon of atomic weight 13 will be produced in substantial quantities, the Sun Oil Company and the Houdry Process Corporation announced.

This heavy carbon isotope has been used in biochemical research for the past two years and now two plants are to be constructed to produce it in larger quantity, increasing from 500 to 1000 times the world supplies of this chemical element.

Carbon 13 is concentrated by thermal diffusion, separating it from ordinary carbon 12. The new plants will bring the cost down to about $40 a gram, whereas the experiments were started with less than a half-gram which cost several thousand dollars to concentrate.

Carbon 13 serves as a tracer in chemical reactions in living and non-living material since by its different weight it can be spotted and told from ordinary carbon.

The work was initiated and carried on by Dr. Aristid V. Grosse of the Houdry organization, assisted by Dr. E. A. Smith, Houdry research director, Dr. Stanley P. Reimann, director of the Lankenau Hospital Research Institute of Philadelphia and others in these two organizations.

THE PRACTICAL VALUE OF CERTAIN TOPICS IN A COURSE IN BIOLOGY

JOHN W. SCHNECK
Riverside High School, Milwaukee, Wisconsin

This study was made as an outgrowth of a desire on the part of the members of the Science Curriculum Committee of the Milwaukee Public Schools to determine both the needs and interests of pupils enrolled in a course in biology. With this in view, a *free choice* questionnaire was prepared and given to a group of 131 chemistry pupils who had had biology the previous year. The questionnaire, headed, "A Survey of the Science Courses" and addressed to the pupil, read as follows:

In order to improve the content of our courses in science, we are anxious to know how useful the things which we tried to teach you actually are. Will you, therefore, help us by expressing your frank opinion in the space provided below?

I. List as many *practical* things, that is, things which you believe will be useful in your daily life—as you can, which you learned in your course in biology.

II. List some of the things which you wish had been included in the biology course.

III. List some of the things which it seems to you might well have been omitted from the course in biology.

The results of this questionnaire were tabulated by the biology teachers. The 77 topics and principles which the pupils suggested were then formulated into a *check list* and returned to the pupils for evaluation with the following instructions:

Listed below, you will find a number of topics and principles which were suggested by last week's questionnaire for inclusion in a biology course. In order that all of you may have the opportunity to express your opinion on the practical worth of each topic, we are asking that you check the list in the following manner:

Check (√) a topic in the *Essential* or "E" column, if you consider it of *great* value in a course in biology.

Check (√) a topic in the *Desirable* or "D" column, if you consider it of *average* value in a course in biology.

Check (√) a topic in the *Unnecessary* or "U" column, if you consider it of *little* or *no* value in a course in biology.

A sample portion of the Questionnaire follows at the top of the next page.

After the results of the student questionnaire had been tabulated, it occurred to members of the committee that an interesting comparison could be made if the same topics were to be rated by a group of biology teachers. In consequence, all teachers who attended the biology section of the Milwaukee County

List of Topics and Principles

I. Plants	E	D	U
1. Care of growing plants			
2. Plant structure			
3. Etc.			

III. Human biology	E	D	U
38. Structure of human body			
39. Function of various parts			
40. Etc.			

TABLE II

Showing the Rank Assigned by 131 Pupils to the 77 Topics in Biology, Together with the Corresponding Rank as Determined by Teacher Opinion

Read Table Thus: Topic No. 38, "Structure of the human body," was ranked *1st* by the pupils. This topic ranked *5th* according to teacher opinion.

Topic No.	TOPIC	Pupil Rank	Teacher Rank
38.	Structure of human body	1	5
63.	Laboratory work by pupils	2	27
39.	Function of parts of body	3	39
40.	Study of diseases	4	21
49.	Sex	5	49
62.	Control of disease	6	17
44.	Study of communicable disease	7	38
43.	Study of venereal diseases	8	58
41.	Study of cancer	9	60
60.	Use of microscope	10	45
42.	Study of tuberculosis	11	38
24.	Dissection of animals	12	72
16.	Bacteria	13	21
45.	Personal health problems	14	1
53.	Food as a factor in health	15	12
51.	First aid	16	51
9.	Reproduction	17	3
10.	Pollination	18	12
54.	Vitamins	19	17
56.	Mental health	19	34
67.	Movies	19	38
29.	Structure of animals	22	12
63.	Lecture demonstrations	23	58
22.	Types of reproduction	24	27
28.	Function of parts of animals	25	27
58.	Conservation and balance of N.	26	12
25.	Control of disease	27	21
36.	Study of mammals	28	45
30.	Breeding of animals	29	65
1.	Care of growing plants	30	51
55.	Psychology & study of minds	31	54
2.	Planting and transplanting	32	60
72.	Scientific method	33	11
66.	Field trips	34	60
46.	Community health	35	21
48.	Eugenics	36	21
14.	Value of plants as foods	37	21
47.	Heredity	38	5
32.	Animals as a source of food	39	17
6.	Photosynthesis	40	1
15.	Medicines derived from plants	41	65
75.	Adaptations of living things	42	34
61.	Principle of genetics	43	51
35.	Study of birds	44	55
33.	Study of fish	45	60
17.	Hormones	46	38
27.	Distinct. between plants & An.	47	55
77.	Plant and animal behavior	48	57
70.	Interdependence of life	49	12
23.	Study of cells	50	5
59.	Nature and origin of life	51	27
3.	Plant structure	52	3
50.	Ductless glands	53	27
6.	How plants obtain food	54	5
5.	Function of parts of plants	55	5
34.	Study of reptiles	56	69
57.	Theory of evolution	57	65
13.	Plant identification	58	72
11.	Grafting	59	70
26.	Classification & identification	60	65
8.	Respiration of plants	61	27
12.	Breeding by buds etc	62	74
73.	Natural selection	63	34
37.	Metamorphosis	64	45
65.	Appreciation of nature	65	34
71.	Vocational suggestions	66	45
52.	Parasitism	67	45
20.	Propagation other than seeds	68	38
21.	Single celled animals	69	38
18.	Study of plant cells	70	27
74.	Survival of fittest	71	38
76.	Leisure time suggestions	72	45
68.	Movie write-ups	73	75
4.	Classification of plants	74	5
31.	Prehistoric animals	75	77
69.	Biographies of scientists	76	61
19.	Plants of the past	77	76

Teachers' Institute held November 2, were asked to evaluate the topics and principles suggested by the student questionnaire.

TABLE III

In Which Topics are Arranged According to the Differences in Ranking Assigned to Them by Pupils and Teacher

* *Read Table Thus:* Topic No. 4 "Classification of plants" was ranked *74th* by the pupils and *5th* by the teachers. This is a difference of +69 in rank.

Based on the arbitrary assumption that a difference of *15* in rank is not significant, there is considerable agreement between teachers and pupils concerning the importance of the topics *following* the double line in the left hand column and those *preceding* the double line in the right hand column.

Topic No.	*Topics for which the teacher ranking is* higher *than the pupil ranking* — TOPIC	Pupil Rank	Teacher Rank	Difference
*4.	Classification of plants	74	5	+69
5.	Function of parts	55	5	+50
6.	How plants obtain foods	54	5	+49
3.	Plant structure	52	3	+49
23.	Study of cells	50	5	+45
18.	Study of plant cells	70	27	+43
7.	Photosynthesis	40	1	+39
70.	Interdependence of life	49	12	+37
8.	Respiration of plants	61	27	+34
74.	Survival of fittest	71	38	+33
47.	Heredity	38	5	+33
21.	Single celled animals	69	38	+31
65.	Appreciation of nature	65	34	+31
20.	Propagation of plants	68	38	+30
73.	Natural selection	63	34	+29
76.	Leisure time suggestions	72	45	+27
50.	Ductless glands	53	27	+26
59.	Nature and origin of life	51	27	+24
32.	Animals as a source of food	39	17	+22
52.	Parasitism	67	45	+22
72.	Scientific method	33	11	+22
71.	Vocational suggestions	66	45	+21
37.	Metamorphosis	64	45	+19
14.	Value of plants as food	37	21	+16
69.	Biographies of scientists	76	61	+15
48.	Eugenics	36	21	+15
46.	Community health	35	21	+14
58.	Conservation & balance of N.	26	12	+14
9.	Reproduction	17	3	+14
45.	Personal health problems	14	1	+13
29.	Structure of animals	22	12	+10
75.	Adaptations of living things	42	34	+ 8
17.	Hormones	46	38	+ 8
10.	Pollination	18	12	+ 6
25.	Control of disease	27	21	+ 3
53.	Food as a factor in health	15	12	+ 6
54.	Vitamines	19	17	+ 2
19.	Plants of the past	77	76	+ 1

Topic No.	*Topics for which the teacher ranking is* lower *than the pupil ranking* — TOPIC	Pupil Rank	Teacher Rank	Difference
31.	Prehistoric animals	75	77	− 2
28.	Function of parts-animals	27	27	0
68.	Movie write-ups	73	75	− 2
22.	Types of reproduction	24	27	− 3
38.	Structure of human body	1	5	− 4
26.	Classification & identific.	60	65	− 5
61.	Principle of genetics	43	51	− 8
47.	Distinct. bet. plants & An.	47	55	− 8
57.	Theory of evolution	57	65	− 8
16.	Bacteria	13	31	− 8
77.	Plant and animal behavior	48	57	− 9
11.	Grafting	59	70	−11
35.	Study of birds	44	55	−11
12.	Breeding by buds, etc.	62	74	−12
62.	Control of diseases	6	17	−11
34.	Study of reptiles	56	69	−13
1e.	Plant identification	58	72	−14
56.	Mental health	19	34	−15
33.	Study of fish	45	60	−15
40.	Study of disease	4	21	−17
36.	Study of mammals	28	45	−17
67.	Movies	19	38	−19
1.	Care of growing plants	30	51	−21
15.	Medicines derived from plants	41	65	−24
64.	Laboratory work for pupils	2	27	−25
66.	Field trips	34	60	−26
42.	Study of tuberculosis	11	38	−27
2.	Planting and transplanting	32	60	−28
44.	Communicable diseases	7	38	−31
60.	Use of microscope	10	45	−35
63.	Lecture demonstrations	23	58	−35
51.	First aid	16	51	−35
30.	Breeding of animals	29	65	−36
39.	Function of parts of body	3	39	−36
55.	Psychology and study of mind	31	71	−40
49.	Sex	5	49	−44
43.	Study of venereal diseases	8	58	−50
41.	Study of cancer	9	60	−51
24.	Dissection of animals	12	72	−60

The tables, II and III above, represent a comparison of teacher and pupil opinion on the worth of the 77 topics for inclusion in a biology course.

Findings

1. Out of 131 pupils checking the questionnaire 93 or 71% said they expected to go to college. Thirty-eight or 29% said they did not expect to attend college. While this percentage is much higher than the normal college expectancy at Riverside, it does indicate an interest in and an appreciation of the value of a college education.
2. The median weighted rating for all topics as marked by 131 *pupils* is 211 or 53% of the possible maximum of 393.

   The median weighted rating for all topics as marked by 20 *teachers* is 262 or 67% of the possible maximum of 393. The median weighted teacher rating was 14% higher than the median weighted rating of the pupils.
3. The median *pupil* weighted rating of the topics on "Plant Biology" is 181 or 46% of the possible maximum. This is 7% *below* the pupil median for all topics. The median ***rank*** as signed to the topics on Plant Biology is 54.

   The median *teacher* weighted rating of the topics on "Plant Biology" is 288 or 74% of the possible maximum. This is 7% *above* the teacher median for all topics. The median rank assigned to topics on Plant Biology by the teachers is 27. This is 27 higher than the median rank assigned to the same topics by the pupils.
4. The median *pupil* weighted rating of the topics on "Animal Biology" is 193 or 49% of the possible maximum. This is 4% *below* the pupil median for all topics. The median rank assigned by the pupils to the topics on Animal Biology is 44.

   The median *teacher* weighted rating for the topics on "Animal Biology" is 249 or 63% of the possible maximum. This is 4% below the teacher median for all topics. The teachers' median rank of 45 is essentially the same as the rank assigned to these topics by the pupils.
5. The median weighted rating for the topics pertaining to "Human Biology" as evaluated by the *pupils* was 281 or 72% of the possible maximum. This is 19% above the median ranking for all topics. The median pupil rank is 15.

   The median weighted rating for the topics on "Human Biology" as rated by the *teachers* was 288 or 74% of the maxi-

mum. This is 7% above the median for all topics. The median teacher rank is 27. This is 12 lower than the median rank assigned by the pupils.

6. In the first quartile of the *pupil* weighted ratings, all but two topics viz. laboratory work by pupils and pollination, are from the field of human biology.

   In the first quartile of the *teacher* weighted ratings, only four are from the field of human biology.

7. Of the 24 topics in which the teacher rank was more than 15 *higher* than the rank assigned by the pupils, 16 pertain either to plant biology or theoretical biology.
8. Of the 20 topics in which the teacher rank was more than 15 *lower* than the rank assigned by the pupils, ten pertain to health and five viz. dissection of animals, lecture demonstration, laboratory work, use of microscopes, and movies, have to do with teaching techniques.
9. It seems evident that if a course in biology is to be based on the criteria of student interest, it must be largely centered about the problem of human behavior and health.

LEGION OF MERIT AWARDED TO JOHN F. RIDER

At a formal military ceremony held at Fort Monmouth on the afternoon of 5 February 1946, John F. Rider, Lt. Col., Signal Corps. (retired) was presented with the Legion of Merit medal.

Rider's twenty odd years of publishing and writing experience in the radio field, resulting in the world famous "Rider's Manuals," "The Cathode-Ray Tube At Work," "Inside The Vacuum Tube" and other well known works, enabled him to do an outstanding job during the three and a half years of service with the Armed Forces, for part of his citation for the Legion of Merit decoration reads as follows: " . . . rendered exceptional administrative service to the Signal Corps Publication Agency. . . . His ability to organize and effectively utilize available personnel materially contributed to the preparation, production and distribution of vitally needed technical manuals containing instruction for the installation, operation, maintenance and repair of signal equipment.

"From 26 November 1943 to May 1944, he planned and personally supervised the production of a backlog of 60 vitally needed technical manuals covering radar equipments already in theatres of operation but without adequate instructions for their installations, operation, maintenance and repair. This was accomplished 60 days prior to the completion date fixed by higher headquarters.

"Production from 14 May 1944 to May 1945, under Lieutenant Colonel Rider's supervision as Executive Officer, Deputy Director and Acting Director of Signal Corps Publication Agency successively, reached a total of 1,906 different publications, of which 797 were packed with equipments going direct from manufacturers to the theatres of operation."

COMPUTATIONS IN PRECISION RIVETING

RONALD L. IVES
Dugway Proving Ground, Tooele, Utah

INTRODUCTION

Small precision rivets are normally cut from bar or wire stock, and headed, in place, by use of a staking tool equipped with stumps and punches made for the purpose.

Standard rivet types for use in small work are shown in Fig.

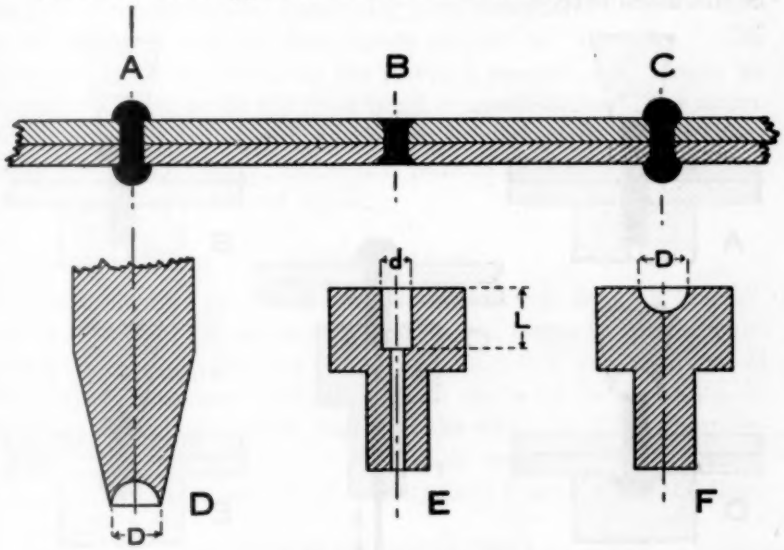


FIG. 1. Rivet types and riveting tools. A—round headed rivet, the most common type. B—countersunk rivet, used where a projecting head is objectionable. C—combination round and countersunk headed rivet, supposedly stronger than either the round or the countersunk type; actually not too satisfactory. D—heading punch for types A and C. E—stump for holding stock while first head is being made. F—stump for holding first round head while second is being made.

1, A, B, and C. The most common form is the round headed rivet, shown at A. The countersunk rivet, shown at B in the same figure, is used where a projecting rivet head would be objectionable. The combined round and countersunk head, shown at C, was intended to have greater strength than the round head, but is seldom used today because the added difficulty of manufacture offsets any gain in strength obtained by the increased volume of the head.

A punch for heading rivets of types A and C is shown in

Fig. 1, D. This punch determines the final shape of both heads. The stump for holding the wire stock while the first head is being made is shown in Fig. 1, E; and that for holding the first head while the second is being made is shown in F.

The riveting process is outlined in Fig. 2. The method shown is that for making round headed rivets. Other types are made similarly, using different staking tool punches and stumps. Rolled head rivets, used in the manufacture of pliers and similar tools, in which the rivet shank also serves as a pivot, will not be discussed here.

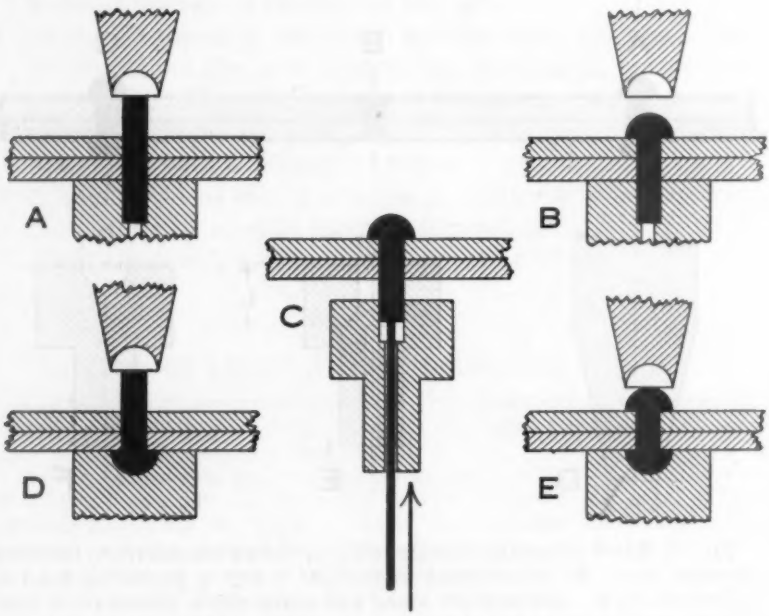


FIG. 2

In A (Fig. 2), the rivet stock is inserted through the two pieces to be joined into the stump (E of Fig. 1). The first head is formed by driving the punch (D in Fig. 1) down upon the stock, as in B. Work and half-finished rivet are freed from the stump by use of a push rod, as in C, the assembly is inverted and placed in the second stump (F in Fig. 1) as shown in D. The second head is made in the same manner as the first, and the completed rivet, still in place in the staking tool, is shown in E.

STOCK LENGTH

After many years of experience, a skilled mechanic can deter-

mine the stock length necessary to make a good rivet by intuitive processes. Many skilled mechanics do not know any mathematics beyond very simple arithmetic, and rely solely upon judgement, which, in some instances, becomes remarkably good.

If the rivet stock is too long, a lumpy rivet head is produced, which is not only unsightly, but likely to be mechanically weak. If the stock is too short, a poor head likewise results. When the metal does not entirely fill the head space, either in the punch or the countersunk portion of the work, a ragged head results, which is mechanically weak, and very unsightly.

In many instances, rivet heads cannot be "fixed up." The stock is work-hardened by the riveting process, and cannot be worked any more. If the rivet head is unsatisfactory, the entire rivet must be drilled out, and a new one inserted. This is time-consuming and costly, and much work is spoiled when the drill is eccentric to the rivet shank.

Computations

To determine the stock length necessary to make a "clean" rivet of any of the more or less standard forms is not difficult. Only simple algebra and simple trigonometry are involved. It is initially assumed that the hole in the work is the same diameter as the rivet stock, and that the rivet stock is incompressible. Slide rule accuracy is all that is necessary—use of seven place tables for these computations is a foolish waste of time.

Round Headed Rivets

To determine the stock length necessary for a round headed rivet, such as is shown in Fig. 3. A, it is necessary to know:—

Thickness of the work (T)

Diameter of the rivet stock (d)

Desired diameter of the hemispherical head (D).

As the rivet stock is cylindrical, the amount of stock necessary to form one hemispherical head is:—

$$\frac{\pi d^2 L}{4}.$$

The volume of the finished head, a hemisphere, is:—

$$\frac{\pi D^3}{12}.$$

As the rivet stock is incompressible, the two are equal, and:—

$$\frac{\pi d^2 L}{4} = \frac{\pi D^3}{12}$$

$$d^2 L = \frac{D^3}{3}$$

$$L = \frac{D^3}{3d^2}.$$

Two heads being required, the total stock length needed will be:—

$$T + 2L \quad \text{or} \quad T + \frac{2D^3}{3d^2}.$$

(All dimensions must be expressed in the same units)

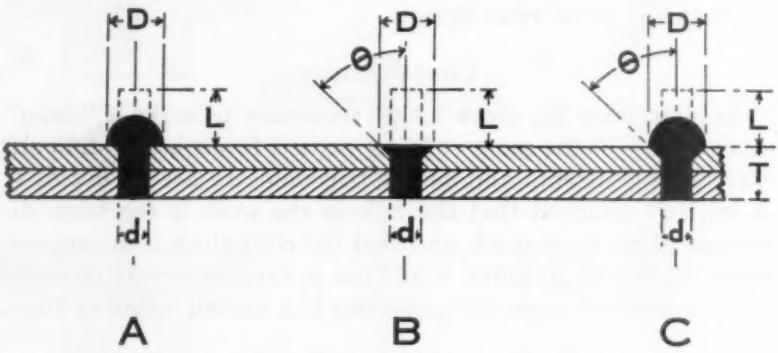


FIG. 3. Dimensions necessary for rivet head computations. Only the upper head is shown in each case.

COUNTERSUNK RIVETS

The volume of material necessary to make the head of a countersunk rivet (Fig. 1, B; Fig. 3, B) is not as easily computed as that necessary for a round headed rivet. Three steps are necessary in this computation: these may finally be combined to produce a single formula.

The volume of material which must be added around the rivet shank to produce a countersunk head may be described as the frustum of a cone of base diameter D, top diameter d, and height $D-d/2 \tan \theta$; minus the volume of a cylinder of diameter d and height $D-d/2 \tan \theta$. This volume may be expressed:—

$$\frac{\pi D^3 \tan \theta}{6} - \frac{\pi d^3 \tan \theta}{6} - \frac{\pi d^2(D-d)}{8}.$$

Simplifying

$$\frac{\pi \tan \theta}{2}\left[\frac{D^3-d^3}{3} - \frac{d^2(D-d)}{4}\right]$$

stock extension supplying this volume is:—

$$\frac{\pi d^2 L}{4}$$

and, as the material is incompressible, the length of the stock extension necessary to form one head is:—

$$L = \frac{2 \tan \theta}{d^2}\left[\frac{D^3-d^3}{3} - \frac{d^2(D-d)}{4}\right].$$

Two heads being necessary on a rivet, the total length of the stock is $T+2L$.

Combined Heads

The volume of material necessary to form a single combined head (Fig. 1, C; Fig. 3, C) is the sum of the volumes necessary to form a round head and a countersunk head. This may be expressed:—

$$L = \frac{D^3}{3d^2} + \frac{2 \tan \theta}{d^2}\left[\frac{D^3-d^3}{3} - \frac{d^2(D-d)}{4}\right]$$

and the total length of stock necessary to form this type of head is, again, $T+2L$.

Other Heads

The foregoing computations and derivations indicate the general method to be followed in computing stock extension necessary to supply the material for a rivet head. With many types, the computations become so complex that trial and error is quicker than direct computation, although in most instances rough computations will greatly reduce the number of trials necessary.

Limitations

Perusal of the preceding sections may indicate to some that any rivet measurement can be determined by simple computation. This is theoretically true; only with theoretically perfect materials. Whenever the rivet shank is upset during riveting; particularly when the surrounding work gives under pressure; or whenever the rivet stock changes volume during work hardening; some corrections must be made.

These corrections, when dealing with hard materials, such as iron, brass or phosphor bronze, are usually negligible. When soft materials, such as aluminum and its alloys, are riveted, particularly with relatively hard rivets, the corrections are far from negligible, sometimes amounting to 20%.

In consequence, although computations will save much time, error, waste, and work spoilage, some testing of an actual rivet in a sample workpiece is always desirable before the work design is "frozen."

Conclusions

The outlined computations in previous sections give exact theoretical values for the stock extension necessary for the construction of three types of rivet head. The same general methods can be used to determine the theoretical stock extensions for heads of other types.

In practice, theoretical values will prove satisfactory when relatively hard materials are used; and will be somewhat unsatisfactory with soft materials.

Slide rule accuracy is adequate for all computations. Use of more accurate computations is unnecessary, as the data upon which the computations are based is not of a high order of accuracy. Deviations of materials from theoretical perfection limit the utility of computation so that, in all cases, a practical test should follow computation. Mathematics does not, and should not, displace practical testing; but it should, and in most instances does, reduce the amount of trial and error by a gratifying percentage.

Acknowledgements

The writer is indebted to Capt. R. A. Avery, CWS, for use of photographic facilities in connection with the diagrams in this paper; and to T/4 Evelyn L. Kroona, WAC, for stenographic assistance.

HISTORY OF ARITHMETIC*

II

WALTER H. CARNAHAN
Purdue University, Lafayette, Ind.

At the close of the first chapter of the history of arithmetic, I told you something about how our common fractions came to be written as they are today.

Decimal fractions were first written as we write them about 400 years ago. The idea of writing them as we do had gradually grown up in different parts of the world. It is such a convenient way that it is hard to see how it could be improved.

One of the chief uses of decimal fractions has long been in solving per cent problems. 500 years ago they used per cent just as we do today, and, especially in finding interest on money, their problems sound much like ours. The per cent sign with two little o's and a mark between them was first used about 300 years ago.

Division of common fractions was considered to be a hard subject in ancient times just as it is today, and several ways of performing the operation have been used. *You* devide by a fraction by inverting the divisor and multiplying. This is the latest of all methods to be used, although men knew how to use it 1,400 years or more ago. At that time, however, they preferred two other methods. One of these was what they called cross multiplication, and the other was to reduce fractions to common denominators and then divide the numerators. You might like to look up these methods in a history of mathematics. Once in a while you still see a person use one or the other of them.

Perhaps you know how to check addition and other processes by casting out 9's. It is a very good way to see whether you have done your work correctly. This method has been known and used for more than 1,000 years. The Arabs were first to use this check. They also knew how to check by using 11's, 13's and other numbers. For hundreds of years all arithmetic books taught the

* The articles of this series are from scripts of broadcasts over radio station WBAA. This series is a part of the Purdue University *School of the Air*. There is one broadcast each week on some subject of mathematics. The first series had the general title *Mathematics Is Where You Find It* and ran for thirteen weeks. A second series of thirteen broadcasts has the title *Mathematical History and the Men Who Made It*. The articles as here given are in the exact words in which they were broadcast. They have been timed to be read in thirteen and a half to fourteen and a half minutes, at the rate found most effective for understanding by the radio audience. Rebroadcasting of these talks in the original form or with adaptations is permitted. Write to the author for specific permission for their use.

check by 9's then about 150 years ago books dropped out the check; but about 50 years ago it again got into many school books.

The old Greeks had two names for the subject we call arithmetic. When they wanted to speak of such operations as finding area or interest, or costs, they used the word *logistica*. When they wanted to talk about less practical but equally interesting number relations, they used the word *arithmetica*. Today we still have the two parts of the subject, only we use the expressions *arithmetic* and *theory of numbers*. Now you learn and use arithmetic; some time you may want to know something about the interesting subject *theory of numbers* which you can study in college.

Looking into arithmetic books of other days and other lands is like looking in on the daily lives of the people themselves. We can thus learn what interest rates were charged by banks and money lenders, the cost of shipping freight, how men invested capital, and even how dishonest men evaded the law.

Let us open the arithmetic books of the Babylonians of 4,000 years ago and see what we can learn about how arithmetic was used then. As a matter of fact, we do not open a book at all but turn over tablets made of clay on which the business transactions were recorded. From these we learn that men loaned money and charged interest just as we do today. For example, we learn that farmers borrowed money to tide them over while they were growing their crops. Interest rates were high, often as high as $33\frac{1}{3}$ per cent, especially if the farmer had bad luck and could not repay the loan on the time.

In that ancient time, prosperous business men employed agents and salesmen just as we do today. The law recognized that such an agent was entitled to part of the profits of the business. But if he mismanaged the business, he was compelled to pay twice the value of the capital entrusted to him.

We also learn that in that far away time men mortgaged their homes and their businesses, just as we do today. They formed partnerships and conducted businesses, each man putting in whatever capital he had, although capital was usually oil or fruit or sheep or flour rather than money.

About 1,000 years after the Babylonians, the Phoenicians became great international merchants. They sailed out on ships from Tyre and Sidon at the East end of the Mediterranean Sea, or sent caravans east and south to India and Egypt. They

bought tin in England and amber in Denmark. They had fleets of freight ships and they took the culture of Greece and the east with them. It is unfortunate that we cannot look into their arithmetic books or business records because they left none. No doubt they used the abacus in their calculations and recorded their business transactions in the number system borrowed from the Greeks. It is practically certain that they formed partnerships and corporations, borrowed and loaned money for interest and had ways of dividing profits and losses fairly.

During the 500 or more years when Rome ruled the world, international business reached a new high, and arithmetic was more extensively used than ever before. Many books were written during this time and some of these have come down to us. From them and from others based on them, we learn a great deal about the arithmetic of the time and the business practices of the traders. For a long time, the Roman business men had a reputation for honesty and fair dealing. And, of course, Roman soldiers maintained good order so that stealing and robbing of merchants was not much to be feared. More than at any time before Roman days or for a long time after the fall of Rome, overland roads and sea lanes were free of dangers, and traders could come and go freely. However, ships were small and subject to many mishaps. Some of the arithmetic problems of the time are based on the difficulties of shipping. Here is a problem taken from an ancient arithmetic which illustrates this point:

"Two ships 20,000 stadia apart weighed anchor to sail straight toward each other. It happened that the first one set sail at daybreak with the north wind blowing. Toward evening, when it had gone 1,200 stadia, the north wind fell and the southwest wind rose. At this time the other ship set sail and sailed 1,400 stadia during the night. The first ship, however, was driven back 700 stadia by the contrary wind, but with the morning North Wind it was driven ahead in the usual manner of outward sailing while the other went back 600 stadia. Thus alternately night and day, the ships were carried along by a favorable wind and then driven back by an unfavorable one. I ask how many stadia the ships had sailed in all when they met."

How would you like to meet that problem in your lesson for tomorrow?

Like merchants of other lands, the Romans used the abacus in making calculations and, of course, recorded facts in the difficult Roman numbers. They borrowed and loaned money, had

banks and offices, hired agents and laborers much as we do today.

During the times which we call in history the Dark Ages, that is, about a thousand years ago, the world was in a very bad way, and business had lots of troubles. Roads were in bad condition so that moving freight by land was almost impossible. Robbers were on all the roads, and even the men who were supposed to maintain law and order became robbers. Shipping on the water was equally dangerous because of pirates. Much of the business was transacted at fairs where peddlers and salesmen as well as farmers and manufacturers gathered to show and sell or trade their products. Much of the money was counterfeit and worthless, so men preferred to trade or barter. A man who had a pig and needed a coat would take the pig to the fair and try to find a tailor who would trade him a coat for his winters meat. Arithmetic books of the time reflect this custom of bartering. Here is one of the problems from a school text of the time:

"Two men barter cloth for wool. A bolt of cloth is worth 12 lire in cash or 15 lire in barter. At the end of 10 months, a hundredweight of wool will fetch 20 lire cash or 24 in trade. When should the bargain be made and how much wool should be paid that the exchange may be equal?"

We have told of the high interest rates charged in ancient Babylon. Arithmetic books of the Dark Ages indicate that interest rates were still very high at that time. Here is an old problem of nearly one thousand years ago that shows that interest rates of about 20 per cent were not uncommon:

"A certain man puts one denarius at interest at such a rate that in 5 years he has two denarii, and in every 5 years thereafter the money doubles. I ask how many denarii he would gain from this one denarius in 100 years."

Students of advanced algebra will see in this problem a geometric progression, and all of you will wonder whether this man will live one hundred years to collect his profits, but it is evident that the rate of interest charged is quite high. You might compare it with the 2% or 3% on our government bonds, or with 5% interest on many home loans. On the other hand, you might compare this rate of a thousand years ago with the 40% charged by some small loan companies today.

High interest rates always have a tendency to make a few persons very wealthy and many persons very poor. That is the

way it became in Europe during the Dark Ages. The Christians did not believe such a condition was morally or spiritually right and spoke out against it. They even went so far as to disapprove of charging interest at any rate. For this reason, lending of money for interest and taking mortages came to be thought of as evil. And yet very few persons would lend money if they could get no interest. And so it came about that money lenders tried to lend money or invest capital for profit in strange ways so that they could not be condemned by their neighbors. One such scheme was known as a rent charge. A man who wanted to borrow money would give the lender a house or other rentable property. The lender would keep this house and collect rent on it until he had collected the amount of the loan plus interest. Of course, he did not tell his priest he was collecting interest; he only said he was collecting rent on the house for what the owner owed him. The arithmetic text books of 700 years ago had problems based on this unusual arrangement between borrower and lender. The poor school pupils had to find out not only how many months the lender could keep the house, but how many days, hours, minutes and seconds.

Stocks and bonds were subjects that did not bother school pupils until comparatively recent times. The first stocks were bought and sold just over 300 years ago. The bankers of Holland were the first to deal in them. Of course, school arithmetic books soon included problems about stocks and bonds, and for over 300 years now this subject has been in the books.

Insurance is another subject that none of the text books of ancient times had to deal with. Ships and cargoes were insured in the days of ancient Rome, but there seems to have been no system to the business, and school pupils did not have to solve problems based on insurance rates. When pirates were active, rates were high, and when the Roman Navy had piracy under control, insurance costs went down. Of course, there were land robbers also that made insurance of goods sent by camel or pack mule necessary, but we know little about insurance except on the sea. A more frequent way of a merchant insuring himself against loss was to send his goods in a number of ships so that if one were lost the others might make enough to take care of the lost capital. Today we have a saying, "Don't put all your eggs in one basket." The Romans would have said, "Don't put all your goods on one ship." Systematic and scientific treatment of insurance problems began about 250 years ago, and since that

time textbooks have had problems about insurance. For a long time, books had problems only on insurance of ships and cargoes. About 100 years ago books began to have problems about fire insurance, and life insurance problems appeared about the same time.

It is clear from these illustrations that textbooks in arithmetic reflect business practices of the times in which they are written. Perhaps there will some day be atom bomb insurance.

Only in recent years have arithmetic books begun to place emphasis on the kind of problems the average citizen has to meet in his daily affairs. The buying of groceries and clothes, paying the dentist, financing an automobile and planning for a vacation are far more real to many persons than compound interest, and people a thousand years from now looking into our arithmetic books will see how important we find these things to be.

NEW EDITION OF SCHOOL HEALTH PAMPHLET PUBLISHED BY U. S. OFFICE OF EDUCATION

The U. S. Office of Education announced today the publication of a revised edition of its widely used pamphlet, "What Every Teacher Should Know About the Physical Condition of Her Pupils."

Since it was first issued 21 years ago, this pamphlet has served as a handbook for teachers interested in protecting and promoting the physical welfare of the children in their classrooms. Increasing interest among teachers, as well as advances in our knowledge about child health, has made it necessary to revise the original text. The new text was edited by the author of the earlier edition, James Frederick Rogers, M. D., formerly Consultant in Hygiene, U. S. Office of Education.

The foreword emphasizes the importance of the teacher's position as the "keystone" of the health examination service since her observance of her pupils is often the first point at which communicable diseases and physical defects are noted. Where the services of school nurses or physicians are infrequent or unavailable, the teacher's importance increases. Although the average length of life has greatly increased, children are still exposed to bacterial hazards and continue to come to school with defective eyes, ears, and other organs, due to malnutrition, disease, or other causes.

The pamphlet stresses the importance of health appraisal, and discusses what teachers should know and do about weighing and measuring, recognizing signs, symptoms, and incubation periods of communicable diseases including colds, daily inspections and continuous observation, records, and the use of the thermometer. It also discusses the training of teachers. A chart of Snellen letters for testing vision is included.

Copies of Pamphlet No. 68 (Revised 1945) "What Every Teacher Should Know About the Physical Condition of Her Pupils" may be purchased for 10 cents each from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

A UNIVERSAL SUBJECT—GEOGRAPHY—FOR THE SECONDARY SCHOOL

MINNIE E. LEMAIRE
State Teachers College, East Stroudsburg, Pennsylvania

The great national interest in the study of geography with emphasis on the human point of view has rolled in like a great tidal wave. However, geographers hope that it is not just a tidal wave, high now to disappear tomorrow. We, as a nation, realize our inadequate training in this field of knowledge. At the present time we do not have trained geographers available for all the needs and for the various levels of school, particularly in the high school field. Until recently we have been politely told that geography is for the elementary school. Many of us have been conscious of the great gap in the secondary school, have tried to gain access by peaceful means, with little luck. Today we have ridden in on the blaak horse of war.

We prefer to think that the conscientious study of peace with its need for an understanding of peoples, for an appreciation of the fundamentals of trade, and for a more complete and correct concept of international affairs will prove the value of geography and will accord the subject its proper place along with other basic and fundamental needs as reading, mathematics, language, history, and such. Geographers become humble when they consider the tremendous responsibility which rests on their shoulders in their cooperative task to make this great nation an integral part of a peaceful world.

Geography has definitely assumed its role as an essential constituent of the modern secondary school curriculum. Today geographers and high school administrators are not discussing and attempting to prove the great value which accrues from the study of this fascinating subject but rather are formulating plans to incorporate it in the course of study. The organization and selection of pertinent, adequate, and necessary phases of geography, adaptable to the proper level and needs of the students, require further consideration, study, and trial. This paper purposes to present a few of the fundamental ideas of geography, just threads of thoughts upon which folks may start to base extended thought. Possibly from this consideration a point of view may develop or new light on an already well evolved point of view may emerge.

High school youngsters have reached a stage where they are pretty much floundering about, not quite sure of themselves, yet desiring something on which to hold, something they can see or feel, something real. They must build the present on the past even as they project themselves into the future. Thus a study of items which are common factors throughout life will meet this desideratum very easily and nicely. At the same time the demand for a practical, utilitarian, and interesting subject must be satisfied. Even though this last requirement is stressed, the sense of appreciation need not be dimmed because an increase in information and in understanding should in turn enlarge the capacity of the student for a more wholesome appreciation of the world and its peoples.

What then constitute some of these factors which permeate through the whole of life, which need a more thorough comprehension and appreciation, and which can serve people in a useful effective capacity? Many things go on day by day and year by year with little alteration by the human race. The first of these constitutes what might well be termed the earth-sun relationships. From this can be derived the varying length of the day and night (sunlight and no sunlight periods). Knowledge of this factor can then be spread to some of the principles of navigation, quite essential to this air-age era. Projecting this farther into the future, if, as scientists tell us, we shall derive heat and power from solar radiation, then even more important will become such information. Not only is knowledge of the daily routine of rotation valuable but also is the yearly movement of revolution which accounts for the changing seasons and the differing angles of insolation.

Although more and more time is being spent in the air by mankind, the majority of us remain on the earth most of the time. A more thorough acquaintance with the surface of the earth, particularly the land, is entirely within the realm of possibilities for high school students. One of the greatest values presented here comes from actual observation—"to see is to believe." Everyone needs to have his eyes opened to the world about him and to view it accurately. When an area cannot be visited in person then training in map reading, another excellent skill, can be brought into use. The concept of constant change and development over a long period of time is gained here with the study of the work of running water, of wind erosion, of waves, etc. A rather specialized, yet useful, aspect of the earth's

surface is oceanography which fits into a discussion of navigation problems faced by our great merchant marine fleet.

The air continuously emcompasses the whole earth and from it derives the weather. Certainly no other feature of our natural environment attracts so much attention or so much comment. An everyday occurrence for everyone—an everyday common talking point for everyone! Yet the appreciation of the why's and the wherefore's of this daily event have been sadly neglected in the past. Today meteorology for the aviator, for the farmer, and even for John Q. Citizen has reached new heights and has stimulated the consciousness of everyone as to its tremendous value in a far broader program than heretofore realized. Again the advantage of careful observations presents itself in the reading of instruments and in detecting such phenomena as clouds, sun-dogs, and the various forms of precipitation.

Economic and commercial geography enables students to better solve and prize those essentials of life, food, clothing, shelter, and fuels which their parents must provide for them and which, in turn, they will provide. The apparent ease with which some of these requisites appear in a youngster's life can be easily dispelled when the toil, the transportation, and other pertinent facts have been correctly presented, studied and interpreted.

Our thoughts have been directed in the last decade, particularly, to the conservation of our natural resources. The war period has crystallized the necessity for action with specific items. This great concept of saving and preventing waste cannot be lost and must be built to include items, not only of immediate concern, but also of far more reaching consequence over a long period of time. The collection of paper to help preserve our forest areas still demands attention as well as other phases of forest conservation such as reforestation, fire prevention, and proper cutting. In addition to proper maintenance of the forest resources, inclusion must be made for an adequate comprehension of the conservation of wildlife, soil, minerals, water, and human resources.

Above all other common factors is man himself as one of many people. In this phase geography can play its greatest part and make its most significant contribution. The study of people in relation to their natural environment constitutes the backbone of geographic interpretations. The proper place to begin the analyzation of people is right at home in the local community. The next tendency will be to move out to the state, then to

include the nation, and finally to encompass the world. With a well established base of an understanding of peoples excellent world interrelationships should evolve. If students can learn the reasons for differences in culture among people and really appreciate these differences, then they will perceive what other peoples have to offer them and what they, themselves, have to contribute to the citizens of the world.

Geography possesses unlimited potential value. When well taught by well prepared teachers who enthusiastically accept the principles and tenets of geography, remarkable results of life-long endurance and profit are attained.

FACTS AND FIGURES

3,000 mothers die needlessly each year as a result of childbirth.

31,000 babies die needlessly each year in their first year.

400,000 children have tuberculosis.

500,000 children have rheumatic fever or heart disease.

980,000 children have congenital syphilis.

100,000 children are inmates of institutions for the dependent and neglected.

250,000 children come before juvenile courts.

4,000,000 children have lost one or both parents; 21,000 of them are orphans of men who died in World War II.

20,000,000 children need dental care.

1,800 counties have no full-time public health unit.

1,000 counties have no public health nurses.

1 doctor is needed to serve 1,500 people but 853 counties have 1 doctor to 3,000 or more people, and 81 counties have no practicing physician.

60 per cent of the children under 15 are in places of less than 10,000 population where only 4 percent of our pediatricians practice.

Instead of the present total of 1,750 child-welfare workers, the Nation needs 13,000.

At least 1,400 child-guidance clinics are needed for children with personality difficulties.

NEW RESEARCH LABORATORIES FOR RUBBER INDUSTRY

Ground has just been broken near Brecksville, Ohio for new research laboratories for the B. F. Goodrich Company on a 260-acre tract of rolling land almost exactly halfway between Akron and Cleveland. Present plans call for five separate completely air-conditioned buildings built of gray brick. The groundbreaking was a part of the celebration observing the 75th anniversary of the founding of the company.

This building site was selected because of its freedom from dust, cross-country electric lines, vibration and noise. It will permit delicate operations that cannot be carried on close to industrial or manufacturing operations. The new plant will replace research laboratories in Akron, where the company's first laboratory was established in 1895.

SOME MATHEMATICS OF THE HONEY COMB[1]

R. F. GRAESSER
University of Arizona, Tucson, Arizona

A honey comb presents an interesting minimal surface problem. It is usually contained in a square wooden box about four inches on a side without top or bottom. If we examine an exposed side of a comb, it seems to consist of little cells with thin walls of wax. These cells are apparently regular hexagonal prisms. If we cut through the comb, it is found that the cells do not extend entirely through the comb but terminate near the middle so that there is a separate layer of cells on each side of the comb. It is a possible but very tedious task to separate one of these cells from the comb. If this is done, the inner end is found to be pointed and bounded by three apparently congruent rhombic faces. The planes of these faces form a trihedral angle with its vertex in the axis of the cell. If we assume these observations to be correct, the bee's cell, so-called, has the form of Figure 1. We have a regular hexagonal prism truncated by three planes making equal angles with the lateral edges at equal distances from the base. The problem is at what angle should these planes cut the lateral edges in order to obtain a minimal surface for a cell of given volume?

In Figure 1, let h equal the longer lateral edge, $h-x$ the shorter. The cell consists of three truncated right rhombic prisms, such as $ABCD-EFGP$, all congruent. Holding $EB=DG=h$ fixed, imagine the truncating plane of $ABCD$ rotated about BD. If the rotating plane is perpendicular to the lateral edges of the cell, we have a right rhombic prism. If it is then rotated to a new position, the triangular pyramid cut from the right rhombic prism on one side of BD is congruent to the triangular pyramid added on the other side of BD. The volume of the rhombic prism is, therefore, independent of the position of the plane of $ABCD$ if h is held fixed. Hence the volume of the whole cell is independent of θ, where θ is the angle which the plane of $ABCD$ makes with a right section of the right hexagonal prism forming the cell.

The problem is then to choose θ so that, with h held fixed, the area of the cell is a minimum. Let a equal a side of the regular hexagonal base of the cell. Then the area of the base is

[1] See W. W. R. Ball: Mathematical Recreations and Essays, Eighth Edition, Chapter VIII for a more complete but less detailed discussion.

$$\tfrac{3}{2}a^2\sqrt{3}. \tag{1}$$

Also $x = HI = IC \cdot \tan\theta = a/2 \tan\theta$, since $OC = a$. The area of the lateral face of a cell is equal to $\frac{1}{2}(2h-x)a = \frac{1}{2}(2h - a/2 \tan\theta)a$ so that the lateral area of the cell is

$$3\left(2h - \frac{a}{2}\tan\theta\right)a. \tag{2}$$

Whatever the value of θ the top face of any right rhombic prism

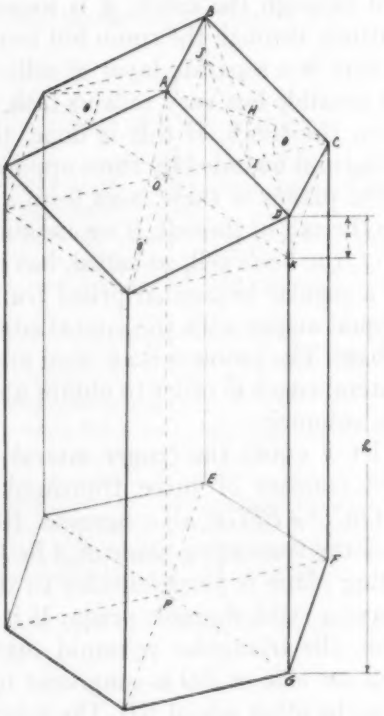


FIG. 1

will be itself a rhombus. For example, $ABCD$ is clearly a parallelogram and BC is equal to CD since they are corresponding sides of the congruent right triangles DKC and BJC. The shorter diagonal AC of $ABCD$ is equal to $OC \cdot \sec\theta$ equal

$$a \sec\theta. \tag{3}$$

The longer diagonal BD is equal to JK, a line joining alternate vertices of a regular hexagon of side a. It is, therefore, equal to

$2a \sin 60°$ equal

$$a\sqrt{3}. \tag{4}$$

Since the area of a rhombus is one half the product of its diagonals, the area of $ABCD$ is $\frac{1}{2}a^2\sqrt{3} \sec \theta$, and the area of the top of the cell is

$$\tfrac{3}{2}a^2\sqrt{3} \sec \theta. \tag{5}$$

Adding (1), (2), and (5), we obtain the area S of the cell, which we wish to minimize by varying θ.

$$S = 3\left(2h - \frac{a}{2}\tan\theta\right)a + \tfrac{3}{2}a^2\sqrt{3}\,(\sec\theta + 1)$$

$$S' = -\tfrac{3}{2}a^2 \sec^2\theta + \tfrac{3}{2}a^2\sqrt{3} \sec\theta \tan\theta \tag{6}$$

$$S'' = -3a^2 \sec^2\theta \tan\theta + \tfrac{3}{2}a^2\sqrt{3}\,(\sec^3\theta + \tan^2\theta \sec\theta). \tag{7}$$

Setting (6) equal to zero, we obtain

$$\sqrt{3} \tan\theta - \sec\theta = 0.$$

Since $\sec\theta$ cannot vanish, $\sin\theta = \frac{1}{3}\sqrt{3}$. Substituting from this in (7), the result reduces to $\frac{9}{4}a^2\sqrt{2}$, which shows that $\theta = \sin^{-1}\frac{1}{3}\sqrt{3}$ makes S a minimum.

Now let 2ϕ equal the smaller angle of one of the congruent rhombic faces of the cell. The tangent of ϕ equals half of the shorter diagonal of the rhombus divided by half of the longer diagonal. By (3) and (4) $\tan\phi = \frac{1}{3}\sqrt{3} \sec\theta$. If θ has the value $\sin^{-1}\frac{1}{3}\sqrt{3}$ necessary for a minimal surface, then $\sec\theta = \frac{1}{2}\sqrt{6}$, and

$$\tan\phi = \tfrac{1}{2}\sqrt{2}. \tag{8}$$

Hence

$$\tan 2\phi = \frac{2\tan\phi}{1 + \tan^2\phi} = 2\sqrt{2} = 2.828427,$$

and

$$2\phi = 70°31'44''.$$

This value of 2ϕ seems to be verified by measurement so that it appears that bees so construct the pointed ends of their cells as to use a minimum amount of wax.

There is also an interesting connection between the bee's cell and the polyhedron known as the rhombic dodecahedron shown in Figure 2. To see how this polyhedron can be formed, we may

dissect a cube into six congruent regular square pyramids the diagonals of the cube forming their lateral edges and the faces of the cube forming their bases. If these six square pyramids are placed with their bases coincident with the faces of another

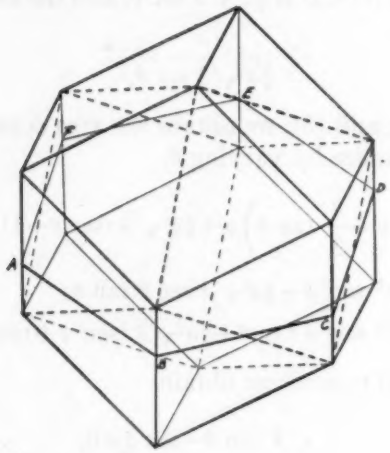


FIG. 2

equal cube, the polyhedron thus formed is a rhombic dodecahedron. The edges of the inner cube are represented by dotted lines in Figure 2. The dihedral angles at the bases of the square pyramids are each 45°. Hence two triangular lateral faces of the square pyramids on adjacent faces of the inner cube will lie in the same plane. These two congruent triangular faces form a face of the rhombic dodecahedron, and this face is, therefore, a rhombus. An edge of the inner cube forms the shorter diagonal of each rhombic face, and, since the cube has twelve edges, our polyhedron has twelve faces. Hence it is a dodecahedron.[2] Let us call the smaller angle of one of the congruent rhombic faces 2β and calculate it. As before $\tan \beta$ equals half the shorter diagonal of the rhombus divided by half its longer diagonal. If e equals the edge of the inner cube, half the shorter diagonal is e divided by two. Half the longer diagonal is equal to half the diagonal of a square of edge e or $\frac{1}{2}e\sqrt{2}$. Dividing

$$\tan \beta = \tfrac{1}{2}\sqrt{2},$$

and it follows from (8) that the faces of a rhombic dodecahedron are similar to those that form the pointed end of a bee's cell.

[2] If the reader cares to take the trouble to construct a pasteboard model of the rhombic dodecahedron, this will help to clarify the discussion.

Since the lateral edges of three of our congruent square pyramids were coincident in a diagonal of the cube which we originally dissected, each dihedral angle formed by two triangular faces of one of our square pyramids is 120°. Since all dihedral angles of the rhombic dodecahedron are dihedral angles of these square pyramids, all dihedral angles of the rhombic dodecahedron are 120°. If a diagonal of the inner cube is bisected perpendicularly by a plane, such as the plane of *ABCDEF* in Figure 2, this plane separates the cube, and, therefore, the rhombic dodecahedron, into two congruent parts. It is easily seen that there are six edges of the rhombic dodecahedron which are parallel to any diagonal of the inner cube. Hence any plane perpendicular to a diagonal of the cube is perpendicular to six equally spaced edges of the dodecahedron, and the section is an equilateral hexagon. Since the angles of this hexagon are all plane angles of dihedral angles of the rhombic dodecahedron, the hexagon is equiangular and, therefore, regular. If we place one of our congruent halves of a rhombic dodecahedron with its regular hexagonal section coincident with the upper base of a regular hexagonal prism, the resulting polyhedron has the form of a bee's cell.

Cubes are space filling solids. If alternate ones are dissected into congruent square pyramids as above, and these pyramids attached to the faces of their adjacent cubes, we have our space filled with rhombic dodecahedrons, which are, therefore, also space filling solids. If two adjacent layers of these are cut by two parallel planes bisecting perpendicularly parallel diagonals of the inner cubes, we have in effect the two layers of bee's cells in a honey comb. It is seen, therefore, that the pointed ends of the cells fit exactly together in the middle of the comb.

To summarize our results:

1. A honey comb consists of two layers of cells meeting near the middle of the comb.
2. Each cell has the form of a regular hexagonal prism topped by half of a rhombic dodecahedron. See Figures 1 and 2.
3. The pointed ends of the cells fit together exactly near the middle of the comb.
4. The rhombuses of the pointed ends are so inclinded to the lateral edges as to give a minimum area for a cell of given volume.
5. All the dihedral angles of a cell are either 90° or 120°.

COST FACTORS IN SCIENCE TEACHING

TRAVER C. SUTTON
Cass Technical High School, Detroit, Michigan

Teaching science courses in the school system of a great industrial city is an interesting duty and adventure. Amid the complexities of modern industrial life is a constant need for larger and more varied services from the secondary school science departments, coupled with an insistent demand that good science teaching be accomplished at a minimum cost. It is very difficult to meet this challenge. We agree that a school can be successful so far as the financial responsibility to the community in which it is located is concerned, only when the school administration and teaching staff fully understand and cooperate in the general control of costs. But it should be remembered that efficient science teaching does cost money.

Control of costs is of particular significance in the operation of a secondary school science department. The heads of such departments and their science teachers are in charge of education in the front line trenches, where they can view wasted materials, destroyed supplies, and misused and ruined science equipment. Too often this happens without any attempt being made to control the situation.

Cutting waste to a minimum and developing worthwhile economies are an everpresent challenge to all science teachers. It is important that a teacher should have a feeling of ownership in his laboratories. This feeling of ownership in the school science department is very closely related to loyalty, and develops an advantageous sense of responsibility and good management. When this attitude exists economies are easily achieved.

Many good administrators, as well as teachers, who are thoroughly skilled at both technical and human relation requirements of their work have no desire to do important paper work or to know the costs of keeping a school going. While this is an important part of their school work teachers have, in the majority of cases, received little training in the budgeting of school funds.

Science teachers who have allowed themselves to be pigeonholed in a restricted realm and are unable to see outside, or are uninterested in realities should not read the remainder of this article. However, many teachers feel that they would like to know more about departmental expenses but realize that they

have little opportunity to obtain the desired information. Many good instructors are deeply interested in the teaching of the sciences yet they have grown to feel that their teaching has little relation to costs. This is an unfortunate attitude.

Science people should learn more about school costs. A good science teacher proves in the field of actual practice his knowledge of materials and equipment costs and demonstrates his ability to control them. What a revelation it would be to many science teachers if a "price tag" was placed on all science devices in their laboratories and demonstration rooms. They would find that they are concerned with costs.

Listed below are some specific suggestions made by experienced science instructors as to how one can cooperate in the matter of costs of control and efficiency:

(1) If there are several teachers in the department, maintain regular laboratory and demonstration work neither ahead of nor behind established schedule. If the science department operates in the terms of a planned schedule it results in a maximum of economy and a minimum of waste.

(2) Ruined plumbing is costly to repair or replace. Sinks and containers should be used only for the purpose for which they are designed.

(3) Good teaching demands good apparatus. Teachers should have the courage to report to superiors any inferior substitution in apparatus and equipment received.

(4) School science laboratories are often cluttered with unused and useless apparatus. Teachers should remove all broken and obsolete apparatus. It is silly to have a laboratory crowded with a lot of useless stuff even though it may look important. Be able to determine what to discard and what apparatus is repairable.

Most apparatus companies maintain shops for the repair of their own manufactured items. A few of the larger companies are equipped to handle the repair of nearly any type of scientific apparatus or instrument listed in their respective catalogs. These firms have both instrument and glassblowing facilities. These companies have many years' experience in the manufacture and repair of a wide variety of scientific apparatus. Why not make use of this service? The following suggestions come immediately to mind:

(1) Scientific apparatus in need of repair will, as a general rule, be best handled by the original manufacturer.

(2) When writing to an apparatus supply house concerning items in need of repair full description should be given. The information contained on the nameplate such as the manufacturer's name, model or serial number, and electrical characteristics such as voltage, wattage, etc. should be included to save time and correspondence.

(3) All repair items should be carefully packed, preferably in cartons or wood boxes with plenty of excelsior or crumpled newspaper, and plainly labeled with the name of both shipper and consignee. *A packing memorandum indicating contents is desirable.* Firms make available forms and labels for this purpose upon request.

(4) Many science items which have been in use 15 or 20 years cannot be economically repaired because of changes in over-all design or of component parts. The trip scale is a typical example. To repair a trip scale, a skilled mechanic will spend many hours making new parts by hand; this is a costly operation. New trip scales are produced in large quantities and cost less than $10 each. Hence, a new scale offers much better economy than the repair of an old one. This economy may not be true when applied to higher valued items such as analytical balances.

(5) If some article of laboratory glassware is in need of repair, the teacher should carefully survey it before forwarding. It is almost impossible to seal glass stopcocks if the point of the break is very close to the shell of the stopcock. If a graduated item has been broken, remember that graduations become inaccurate when heated in the blast flame. The repair of breaks in the calibrated portions of graduate glassware is not recommended.

(6) Generally speaking, replacement parts for most apparatus items listed in current catalogs can be supplied from stock. For example: items such as pans, hangers, beams, etc. for scales; pulley sheaves, and boilers for steam generators are readily available. When placing an order for a replacement part, an exact description and, if possible, a sketch or sample of the part are desirable. It is not advisable for the instructor to undertake too elaborate repairs himself or the performance of the apparatus is affected. In that case it would be much better to send the apparatus to the manufacturer for repair.

(7) The manufacture of special items of any kind or, in fact, almost anything which requires special work will be much more expensive than standard stock items. The preparatory work necessary in making special items involves extra expenses which

must be borne by the item. Repair items fall within this class and consequently repair charges sometimes seem high in comparison to the prices of regular quantity production items. If cost is a factor special items of any kind should be avoided.

This article would not be complete without mention of orders, quotations and shipments. These are important. In outlining laboratory requirements and subsequently making out an order, it is frequently advisable for the instructor to use some such guide as pamphlets which science companies make available. These are based on the popular textbooks and manuals used in chemistry, physics, biology and general science. The pamphlets contain suggestive lists of apparatus, supplies and chemicals for the required experiments or course of study. Although the prices indicated in the lists are not in all cases current, on the whole these are sufficiently close to enable the instructor to estimate his budget. In addition, some of the pamphlets have a student check list included for non-returnable items serving as an excellent inventory or guide for avoiding the omission of needed items, and for determining quantities required.

With regard to placing a new order, the teacher should use catalog numbers and full descriptions. The name of the apparatus, the size, and the quantity should be so specified that there will be no doubt in the mind of the order editor as to what is wanted. In writing up an order too often complete specifications, including sizes, etc., are omitted which makes it difficult to supply the exact items desired, and sometimes involves correspondence and delay. The catalog numbers of the firm with which the order is to be placed are always desirable. Specifications that are complete and legible obviate misinterpretations. It is not necessary but advisable to indicate approximate prices as a further guide to the selected items and the approximate total value of the order so that if prices have changed appreciably, approval on any increases can be obtained before shipment is made. On orders for chemicals the grade should always be shown to avoid receiving a technical product when a chemically-pure grade is wanted.

If competitive quotations are necessary, it is wise in preparing the quotation list to use the catalog of a favored firm, as that will set the desired standards. The use of several different catalogs is not desirable from the standpoint of the supply house. A list containing the catalog numbers of only one firm is less difficult to handle, even for the company whose numbers were

not used. All major companies have copies of competitors' catalogs for the purpose of transposing catalog numbers. On competitive bids particularly, it is not desirable to use the catalog of a little known company as that catalog may not be on the file with many other companies. Of course, the use of catalog numbers will not prevent the substitution of the cheapest possible items. It is very important, therefore, to compare individual items on every quotation for quality, as well as for price, and never to rely on the total quoted price as the only indication of the best value. If no catalog numbers are used, then there is absolutely no guarantee of receiving the desired items, or suitable quality items. As a bad example of one possibility, tripod magnifiers have often been quoted by some companies when customers have specified microscopes without catalog number or other specifications.

Orders placed, if possible, during April and May for delivery during the summer will usually assure delivery of the completed order before school opens in the fall. All apparatus houses receive their largest volume of orders during the first two weeks in September with the result that even in normal times shipment of many items is delayed because of the seasonal rush.

All shipments upon being received should be carefully unpacked and compared with the original order for missing items. The usual procedure is for the teacher to lay out all the equipment, placing a check mark on the packing list after each item as it is unpacked and before removing or destroying any of the packing material. If an item is missing a thorough search of the packing material should be made. Frequently a small item which may be packed in an envelope is easily overlooked. Any breakages or damage in transit should be called to the attention of the transportation company while packing material is still available for inspection. This greatly simplifies the problem of filing claim and recovering the value of broken material from the transportation company. The transportation companies are equally responsible for concealed damage as well as apparent damage and must be notified within 15 days after the receipt of a shipment if a claim is to be filed. In connection with breakages and shortages correspondence with the apparatus house should carry full information as to the date of the shipment and the register and invoice numbers.

In addition to the cost factors discussed in the first part of this article there are others of equal importance to consider. For

example: In a large science department there is need for definite daily schedules as an aid in planning each day's teaching job. Such planning includes the following items:

(1) Careful check to see that the proper apparatus and laboratory materials are available at the places where they are to be used.

(2) Make adjustments to meet any emergency conditions.

(3) Keep an up-to-date record of apparatus and materials needed for future demonstration and laboratory work.

There is no doubt that, in the majority of schools, there exists great opportunity to introduce economies in the handling of science materials. The following suggested controls are of practical value.

(1) Before reaching the laboratory the students should be prepared in the *why, when, where* and *how*. The teacher should give instructions clearly and in sufficient detail so that science students do not waste time searching out additional direction information because they are confused as to experiment procedure. In other words they should be ready to use laboratory apparatus and materials in an understanding and fairly efficient manner. If students are prepared to do their laboratory work they will not ruin costly apparatus and waste materials.

(2) In considering science cost factors from all angles we may study with profit what Dr. J. S. Richardson of Miami University has well stated in an article appearing in a recent issue of SCHOOL SCIENCE AND MATHEMATICS. He says: "To the teacher who is interested in the achievement of the scientific method as an outcome of secondary science courses, it seems axiomatic that in the solution of any problem all of the resources which can be brought to bear should be made available. Yet it is a common experience of the science teacher to come upon a certain piece of equipment and realize suddenly that if he had had it in a given situation a few days earlier the learning in that situation would have been greatly improved. A piece of equipment or a book which stands idly on the shelf because the teacher has forgotten or has been unable to locate it had just as well never been obtained. *The storage of these resources should be such that their use is suggested rather than that they be forgotten.* In fact, it hardly seems to be an overstatement that the science laboratory had just as well not be equipped if the equipment cannot be found, or is not available, or does not suggest itself for use in a learning situation."

Because of the constant use of expensive types of equipment and apparatus needed in the teaching of science it is impossible to eliminate all waste. However waste is subject to sensible control. In order to accomplish this result the teacher must do more than just talk about the elimination of waste. He must participate in an active manner in the program to reduce costs or the program cannot be a success.

Although only a few factors of cost as related to science teaching have been covered in this article the reader is able to see that many of the suggestions also apply to the general school organization.

A good organization is essential in order that any program be a success in the struggle to reduce costs. The most important factor in such a program is the teacher. No organization can function without departmental planning as well as general planning. To eliminate unnecessary costs and do a good job of teaching requires the services of the best kind of a teacher. Most science teachers, with proper encouragement, can do the job.

The details of the technique in maintaining an educational budget system are somewhat complicated. The larger the school organization the more complex becomes the budget system. To a very large extent the operating success of the school system, great or small, is determined by the proper directing and controlling of expenditure. This is accomplished by means of carefully worked out budgets which are really estimates of the amount of money or amounts of materials and supplies available for definite periods of time.

NEW APPARATUS FOR PHYSICS AND ENGINEERING

A 100,000,000-volt electron accelerator or betatron for X-rays was perfected; it may also produce other forms of radiation available before only in the cosmic rays.

A 100-ton electronic differential analyzer was announced; no longer needed for secret war research, it was used in solving scientific and industrial engineering problems, for which it was designed.

A tiny oscillator tube, more powerful than any broadcast station, but which gives off its power burst within one millionth of a second, has been used in radar, it was announced.

Automatic radar recording camera was developed that photographs the radar image on the radar oscilloscope while the operator is watching it.

THE INVERSE DISTRIBUTIVE LAW

A. R. JERBERT
University of Washington, Seattle, Washington

In elementary algebra factoring is made needlessly complicated and difficult by the multiplicity of "cases," each of which requires a different "rule." The factoring of x^2-a^2, e.g., has nothing in common with that of $x^2\pm 2ax+a^2$, x^3-a^3, or $ax+ay+bx+by$ The failure to achieve a unified procedure is due to a lack of appreciation of the simplicity and uniformity of the inverse process. Since the distributive law,

$$n(a+b)=na+nb, \tag{1}$$

is the "heart" of multiplication, the difficulty centers on the failure to observe that this principle, *in reverse*, is the "heart" of factoring.

Multiplication is based on the law of signs, the "addition law" of exponents and the commutative, associative, and distributive laws. The "sign law" is easily remembered because of its dramatic appeal, and exponents are readily accepted as a device for abbreviating repeated multiplication. The associative and commutative laws are taken for granted, if indeed, there is any awareness of their existence. The distributive law is, therefore, the one to "conjure with." Unlike the other laws, which operate on a term by term basis, this law demands a "span of attention" which is capable of being distributed over *any* number of terms.

If the multiplier is a monomial as in equation (1), *one* application of the principle suffices. For a polynomial multiplier, *two successive* applications are required. Thus,

$$(x+y\ (a+b)=(x+y)a+(x+y)b=ax+ay+bx+\ y. \tag{2}$$

In the first equality $(x+y)$, treated as a *single* number, plays the part of n in equation (1). In the second one, a and b take over this role. Evidently, the product of two binomials is a quadrinomial, and, in general, multiplying m terms by n terms yields mn terms.

Equations (2) indicate the *successive stages* of a typical multiplication in *equational form*. The prevailing practice, however, is to follow arithmetic analogy and place the multiplier *below* the multiplicand. This arrangement is wasteful of space and "out of line" with factoring which is, or should be, equational. The most serious objection is that the "two-step pattern" of equa-

tions (2) is *buried* under the *avalanche* of terms which result from multiplying "everything" in the multiplicand by "everything" in the multiplier. The anticipatory "bunching" of like terms in columns represents a slight saving in time at the cost of clear understanding, since it tends to *fuse*, and therefore *confuse*, combining procedure with that of multiplication.

The four terms which result from $(a \pm b)^2$ e.g., are packaged into *three* with such dispatch that the *quadrinomial* vanishes from sight. Mathematics teaching is perennially vitiated by an ever-recurring *haste* to attain a highly developed computational procedure at the expense of understanding.[1] The time saved amounts to very little and is lost many times over in the patching process of reteaching or rather *rememorizing*, which is the aftermath of inadequate instruction.

The "special products" are:

$$(a \pm b)(a \pm b) = (a \pm b) \cdot a + (a \pm b) \cdot \pm b$$
$$= a^2 \pm ab \pm ab + b^2 = a^2 \pm 2ab + b^2. \tag{3}$$
$$(x-a)(x+a) = (x-a)x + (x-a)a$$
$$= x^2 - ax + ax - a^2 = x^2 - a^2. \tag{4}$$
$$(x+a)(x+b) = (x+a)x + (x+a)b$$
$$= x^2 + ax + bx + ab = x^2 + (a+b)x + ab. \tag{5}$$

Each "case" follows the pattern of equations (2) and the product *is a quadrinomial*. In equations (3),

$$ab + ab = 2ab,$$

which concentrates the *four* terms into *three*. This is a doubtful gain, however, since it imposes the necessity of *constantly* pointing out the fact that the coefficient of the "middle term" is *two*.

In equations (4) the quadrinomial is "telescoped" into a *binomial* by virtue of,

$$ax - ax = 0.$$

The cancellation represents a simplification but at the cost of *destroying a pattern*. In bookkeeping terms, the elimination of a payment credit and an equal purchase debit represents a saving in recording, and a *loss of information*. In obtaining tangency by the coincidence of two, or more, points, it would be possible to assert that all the points, but one, had "disappeared." It is more

[1] See the author's paper, "Square Root," SCHOOL SCIENCE AND MATHEMATICS, March 1945, pp. 267, 269, 270.

informative, however, to suggest the evolutionary background by describing the "coalescence" as a *multiple* point.

In equations (5) a similar *condensation* results from,

$$ax+bx=(a+b)x,$$

which is a *partial reversal* of the multiplication procedure. A geometrical picture such as Fig. 1 emphasizes the "$ax+bx$" and

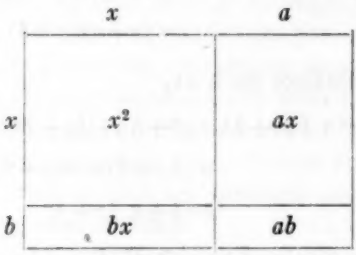


FIG. 1.

only with difficulty lends itself to the "$(a+b)x$" interpretation. A similar geometrization *stresses* the quadrinomial pattern in equations (3) and (4).

The distributive law *in reverse*, i.e., equation (1), read from right to left, is the *key* to factoring. The equation reveals that *one application* of the *inverse* principle suffices to "factor out" the "common monomial factor" n. On the other hand, a quadrinomial such as the third member of equations (2) evidently requires *two successive* "treatments," which are precisely these equations in *reverse* order. This is the entire procedure, except that for "special products" a *preliminary* step is required to overcome the "foreshortening" effect of combining and *restore* the quadrinomial *pattern*.

In factoring $a^2\pm 2ab+b^2$, e.g., we begin by "decombining" $2ab$ into $ab+ab$, which simply *undoes* the last step in equations (3). Employing these equations, therefore, in *reverse* order,

$$\begin{aligned} a^2\pm bab\pm b^2 &= a^2\pm ab\pm ab+b^2 \\ &= a(a\pm b)\pm b(a\pm b) \\ &= (a\pm b)(a\pm b). \end{aligned}$$

In factoring x^2-a^2, the preliminary step *restores* the "missing" terms of intermediate degree by separating 0 into $ax-ax$. Thus, employing equations (4) *in reverse*,

$$x^2-a^2=x^2-ax+ax-a^2$$

$$= x(x-a)+a(x-a)$$
$$= (x-a)(x+a).$$

To factor $x^2+(a+b)x+ab$, the first step is to separate $(a+b)x$ into $ax+bx$. Employing equations (5) *reversely*,

$$x^2+(a+b)x+ab = x+ax+bx+ab$$
$$= x(x+a)+ (x+b)$$
$$= (x+a)(x+b).$$

In a numerical instance such as,

$$x^2+11x+24 = x^2+8x+3x+24$$
$$= x(x+8)+3(x+8)$$
$$= (x+8\ (x+3),$$

the problem of separating $11x$ *suitably* is evidently the same as in the conventional procedure.

The factoring of x^3-a^3 is usually postponed until much later because it represents an even greater *feat of memory* than the "special products" (3), (4), (5). From the present point of view this "case" differs from that of x^2-a^2 only in that it requires *two* terms of *intermediate* degree, viz., x^2a and xa^2, to bridge the gap between x^3 and a^3. Thus,

$$x^3-a^3 = x^3-x^2a+x^2a+xa^2-xa^2-a^3$$
$$= x^2(x-a)+xa(x-a)+a^2(x-a)$$
$$= (x-a)(x^2+xa+a^2).$$

With x^3+a^3, a minimum of "trial and error" will reveal that the sign sequence for the "inserted" x^2a and xa^2 is,

$$+-, \qquad -+.$$

The same procedure, evidently, extends to the factoring of $x^n \pm y^n$. The *motivation* of the concept of degree by employing it as a guide to "missing" terms is a useful by-product of this method.

We conclude, therefore, that factoring may be made as *uniform* and "caseless" as its inverse, multiplication. Just as the latter is merely a matter of employing the distributive law *one* or *more* times, so factoring, conversely, amounts simply to *one* or *more* applications of the "inverse" distributive law. The conventional procedure and the one which we are suggesting are com-

plementary in the sense that "factoring by grouping," which is often omitted in elementary factoring, is the one "case" which we have employed throughout.

Algebra is frequently contrasted unfavorably with geometry because of its "blindness" of procedure. This view is confirmed by the tendency to perform manipulations unthinkingly, with no interest in the individual steps, on the ground, apparently, that the end result is all that counts. Multiplication is an excellent illustration. As conventionally taught, it is a typically "blind" procedure. Following arithmetic analogy, as we have remarked, it is performed haphazardly with no *discernible pattern*. As in arithmetic, also, attention is centered *exclusively* on the end result. Multiplication procedure is therefore simply a *machine* in which the factors are inserted at one end and the "product" emerges at the other.

What goes on *within the machine* is as obscure as the circus trick in which a shaggy dog walks into one end of a box-like "contraption" and reappears close-clipped at the other end. The result is that the factoring of a "special product" such as x^2-a^2 e.g., derives no clue from the *immediately preceding* multiplication. The only recourse, therefore, is to ignore the latter as of no help and simply *recall* the factors. Similarly, each "case" of factoring involves a "by-passing" of the machinery of multiplication in favor of a direct appeal to memory.

Thus, multiplication is "blind" because it has been permitted to become so. The basic pattern of equations (2) is put aside to make way for a "frank" appeal to the analogy with arithmetic multiplication. The latter, however, is completely "blind" in terms of the distributive law because of the masking effect of "carrying."[2] The elimination of the quadrinomial in the haste to achieve a final combined result is consistent with the arithmetic analogy. On the other hand, if the multiplication is performed "equationally," the distributive law stands out *plainly* and the factoring is simply, and literally, multiplication "in reverse." By taking a little interest in the details and observing the pattern, it is evident that multiplication is not only a *clue* to factoring but supplies the entire method.

Making factoring the *step by step inverse* of multiplication amounts to "tunneling through" the product-factor identities from both ends and leads to the sense of mastery which results

[2] See the author's paper, "Algebra and Arithmetic," SCHOOL SCIENCE AND MATHEMATICS, June, 1945, p. 528.

from taking a mechanism apart and putting it together again. The role of memory is reduced to a minimum, since all that is required is an *appreciation* of the distributive law and the fact that it "works both ways." The symmetry of the equality relation is effectively emphasized and as a result of this *two-way* experience, the identities become *automatic* and *effortless*. *Deliberate* memorization is necessary only for propping up a weak understanding.

The objection to the conventional procedure is that from the beginning the intermediate "mechanism" is by-passed, or rather jumbled, in multiplication, and completely short-circuited in factoring. The effect is to substitute memorization for *mastery*. Since the distributive law is basic in the point of view which we are suggesting, it would evidently defeat the purpose completely if this law, in turn, were merely memorized. It should, in fact, be a fundamental pattern of thinking from the 6th grade on.[3] That is to say, it should be thoroughly understood and appreciated and not simply memorized.

Quadratic Equations

To solve,

$$x^2+5x=24,$$

e.g., the obvious procedure is to *leave* the 24 *where it is* and proceed on a "trial and error" basis. Since the roots of an equation of this type are integral (if rational), a very few trials will suffice. The "try and see" procedure is greatly simplified by factoring the left member. Thus,

$$x(x+5)= 4.$$

Assuming $x=2$, 3, etc.,

$$2(2+5)=14, \qquad 3(3+5)=24,$$

so that $x=3$ is one root. From the *symmetry* of Fig. 2

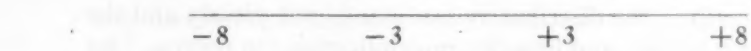


FIG. 2

and the fact that,

$$3\cdot 8=-8\cdot -3,$$

it is evident that the *other root* is $x=-8$. In general, if $x=a$ is *one root* of

$$x^2+kx=L,$$

[3] See the author's papers, "Think of a Number," SCHOOL SCIENCE AND MATHEMATICS, October, 1944, pp. 624-628, and "Algebra and Arithmetic," loc. cit.

the other root is evidently

$$x=-a-k.$$

With an equation of the type,

$$6x^2+x=12,$$

the roots *may* be fractional (if rational) in which event the "trial and error" scheme would be laborious. The substitution,

$$x=y/6,$$

leads to,

$$y^2+y=y(y+1)=72,$$

whose solutions are the *integers* 8, -9, so that $x=8/6$, $-9/6$. The method is, evidently, perfectly general. We conclude, therefore, that the factoring technique for solving a quadratic (for rational roots) amounts simply to the "*first case*" in factoring, i.e., to *one* application of the *inverse* distributive law.

To solve the general quadratic,

$$ax^2+2bx=c,$$

$$x^2+\frac{2b}{a}x=\frac{c}{a},$$

we set,

$$ax=y,$$

to obtain,

$$y^2+2by=ac,$$

$$y(y+2b)=ac.$$

Symmetry suggests,

$$y+b=z,$$

so that,

$$(z-b)(z+b)=ac$$

$$z^2=ac+b^2$$

$$z=\pm(ac+b^2)^{1/2}.$$

If we compare this with the Hindu method,

$$ax^2+2bx=c,$$

$$a^2x^2+2abx=ac,$$

$$a^2x^2+2abx+b^2=ac+b^2,$$

$$ax+b=\pm(ac+b^2)^{1/2},$$

it is evident that the latter "telescopes" the substitutions,

$$z=y+b, \qquad y=ax,$$

into

$$z=ax+b.$$

AVIATION GEOGRAPHY IN THE OAK PARK HIGH SCHOOL*

HELEN S. TURNER
Oak Park and River Forest Township High School, Oak Park, Illinois

During the last few years much has been written concerning the need for and place of geography in the curricula of secondary schools. In these reports there is a wide diversity of opinion as to what type of course should be offered, or where the emphasis should be placed. There are advocates each for social geography, regional geography, economic, political, systematic, global or air age geography. The course given at the Oak Park and River Forest Township High School called "Aviation Geography" is not this so-called Air Age Geography. It developed as an outgrowth from a program which, though more broad than the name indicates, could be classed as physical geography or physiography. The aviation course is now in its sixth year, having been organized in the days before Pearl Harbor. It was devised when flight training was undertaken by individuals and before the days of the large Army and Navy Air Corps programs. The written examinations required by those who were striving for private or commercial licenses demanded a fairly comprehensive knowledge of meteorology and an understanding of maps. Thus the course met a real need in helping prospective pilots. It does not differ radically from some parts of the pre-flight courses that have become part of many curricula these past three years. But there has been continuous effort to keep it what its name implies—a course in physical geography for those who wish to fly.

Since it developed from the physical geography course, the time allotted to it is the same as for any science in the high school—seven 40-minute periods per week, three for class discussion and four for laboratory work. The enrollment is from

* Presented to the Geography Section of the Central Association of Science and Mathematics Teachers, November 23, 1945.

the 3rd and 4th year students and includes both boys and girls. The only prerequisite is a credit in geometry.

It is a full year course, one semester of navigation and one of meteorology. Nearly all of the students start in the fall, but since the work of each semester is distinct some enter the class in February and take the meteorology work first. The first semester is called Navigation. For about 6 weeks the scope of the course is almost identical with the opening section of a physical geography course and the texts used are standard physiographies and Johnson's *Mathematical Geography*. The shape, size, motions of the earth, time, seasons, the earth grid, latitude and longitude are studied.

In this part of the course, the work on seasons stresses the path of the sun throughout the year with no attempt made to consider differences in the intensity of solar radiation. The length and direction of shadows and altitude of the sun serve as a simple introduction to celestial navigation. Actual measurements of the altitude of the noon sun and crude estimates of latitude are made. In these problems the analemma takes the place of a nautical almanac in determining the declination of the sun, and its use initiates discussions relative to mean time and rate of apparent migration of the vertical sun.

Since maps will become the pilot's constant navigational aid, much time is alloted to their study. Methods of projection are first demonstrated in a darkened room with a glass globe and a light. A spherical rose globe covered with paint except for parallels and meridians and a rough outline of North America and a flash light with the bulb exposed are used to illustrate the distortions of the globe grid when projected on cone, plane, and cylindrical surfaces. This demonstration is followed by the mathematical construction of Mercator's and polar gnomonic projections. For drill work on the subject of map scales, air photographs of Oak Park and River Forest are used. These photographs were taken in 1926 at an elevation of 6,500 ft. and thus show great detail. Using them the student draws maps of the community to the scale, 1 in. equals 1 mile, and 1 in. equal to ½ mile. Much drill time is spent in the use of atlases, in determining and expressing latitude and longitude and in correct interpretation of contour lines, color, hachure lines, and standard map symbols.

The last half of the semester is devoted to methods of navigating by contact flight and dead reckoning—and is largely con-

cerned with techniques and procedures of flight plans. But here again, the scientific bases for methods are kept in mind. Thus, for example, the principles of navigation instruments and the earth's magnetic forces are considered, as well as the rule of thumb for solving problems involving compass errors.

Throughout the semester an attempt is made to develop clear thinking, scientific reasoning, precision in definition, accuracy and speed. At the same time the course is made as practical as possible. Current sectional and regional aeronautical charts are used and the student is encouraged to become proficient in the use of various tools such as plotters, and computors.

The time of the second semester is devoted to meteorology. Here, there is an even greater similarity between the physical and aviation geography courses. Both, after a brief introduction concerning the properties of air, begin the real study of weather elements with an examination of the distribution of radiant energy. The regular change of seasons is again considered, but this time the apparent migration of the sun is thought of in terms of its influence on the intensity and duration of insolation rather than as an aid to celestial navigation. This leads logically into a study of weather elements, thermodynamics, humidity, pressure and winds. But whereas, in the physiography course the study of these factors places emphasis on world conditions and culminates in an understanding of climatic types, in the aviation geography the stress is on local daily changes in the weather. The safety of a flight depends on the pilot's ability to read intelligently and to understand weather instruments, maps, codes, and other teletyped messages before the take-off, and then to observe and correctly interpret weather signs while in the air. With this in mind, each element is viewed, not only as to its cause and its effect on weather, but also as to the various instruments used for observing its changes and the codes by which these observations are disseminated. Take for example, the section devoted to wind. The study of the causes for daily and seasonal fluctuation of winds and the relationships existing between wind direction or velocity and pressure is accompanied by (1) regular observations of the wind vane and anemometer, (2) careful practice in using the Beaufort scale, (3) method of showing wind direction and velocity on the daily weather map, and (4) deciphering coded teletyped messages involving winds at the surface and winds aloft.

The section concerning the elements of weather and climate

is followed by units on world pressure belts, air masses, fronts, and the usual life history and movement of cyclones.

Careful keeping of records and daily analysis of current weather over a period of time is followed by a week or more of actual forecasting. This is not done with the intention of making proficient forecasters, but since each written forecast includes the individual's own observations, and interpolations and is followed by his explanation for any failures, it is obvious that he must make frequent observations and careful analysis of the changing weather. This week or two of forecasting by the individual is the culmination of a longer period of analysis of the current weather first by the class as a whole, then by smaller discussion groups, every student being a part of such a group, and finally by each individual on his own. Throughout the semester formal class discussion is interrupted and the existing weather conditions analyzed, whenever it seems advisable to do so.

As is to be expected, all of this meteorology is related to flight and the hazards of aviation are constantly kept in mind, Fog frost, or icing, thunderstorms and line squalls are given special treatment.

The last two or three weeks combine the two semesters. A number of cross country trips are planned using aeronautical charts, synoptic charts, and various teletype coded messages. Simulated trips are studied involving the avoidance of fronts, flight altitudes to avoid turbulance, and icing, and when to cancel flight.

It does not seem wise to judge the value of a course that has been given for only six years, particularly when those have been war years during which unusual opportunities for aviation have developed. Many of the boys who have finished the course have gone into the air corps as pilots, navigators or weather observers. From them have come gratifying reports. But with the change to civilian flying again and the greatly simplified tests now required for certification of pilots, the situation may change. But no matter what the government regulations may be —it seems certain that a pilot needs this fundamental knowledge of navigation and meteorology if he is to have a happy landing.

Brief Outline of the Course

NAVIGATION

I. The earth as a planet

Shape and size
Latitutde and longitude
Rotation and standard time
Revolution and migration of the sun
Methods used to determine latitude and longitude
Map projections and scales
Contour maps
Study of aeronautical chart

II. Dead reckoning
Direction
Compass errors
Wind triangles
A cross country trip
Interception
Double drift
Radius of action

METEOROLOGY

I. The atmosphere (stratosphere and troposphere)
II. Weather instuments and codes
Temperature
Pressure
Wind
Humidity and dew point
Clouds
III. Temperature, insulation, and heat
IV. Lapse rates
V. Planetary winds
VI. Air masses and fronts
VII. Cyclones and anticyclones
VIII. The weather map
IX. Forecasts
X. Icing, fog, thunderstorms
XI. Flight problems

BIBLIOGRAPHY

Books used in the room for reference and class work

SETS

Aerology for pilots. New York, N. Y. McGraw-Hill Book Co., Inc. (Flight Preparation Training Series.) 6 copies.

Air navigation, part one: Introduction to earth. New York, N. Y. McGraw-Hill Book Co., Inc. (Flight Preparation Training Series.) 2 copies.

Air navigation, part two: Introduction to navigation. New York, N. Y. McGraw-Hill Book Co., Inc. (Flight Preparation Training Series.) 20 copies.

Arey, Albert L., and others. *New physiography.* New York, N. Y. D. C. Heath & Co. 27 copies.

Bauer, Hubert A. *Globes, maps and skyways.* New York, N. Y. The Macmillan Co. (Air Age Education Series.) 21 copies.

*Chambliss, W. C. and McDonald, W. F. *Private pilot's handbook.* New York, N. Y. Aerotext Publishing Co. 5 copies.

Goode, J. Paul. *Goode's school atlas.* New York, N. Y. Rand McNally Co. 35 copies.

Johnson, Willis E. *Mathematical geography.* New York, N. Y. American Book Co. 21 copies.

Jordanoff, Assen. *Through the overcast.* New York, N. Y. Funk & Wagnalls Co. 10 copies.

*Lyon, Thoburn C. *Practical air navigation.* Washington, D. C. Government Printing Office. (U. S. Department of Commerce, Civil Aeronautics Bulletin No. 24.) 16 copies.

Maps . . . and how to understand them. Consolidated Vultee Aircraft Corporation. 35 copies.

Pickwell, Gayle. *Weather.* Los Angeles, Cal. Hugh F. Newman & Co. 5 copies.

*Thorpe, Leslie. *The New cadet system of ground school training.* San Francisco, Cal. Aviation Press. 15 copies.

Trewartha, Glenn T. *An Introduction to weather and climate.* New York, N. Y. McGraw-Hill Book Co., Inc. 20 copies.

U. S. Navy Department, Bureau of Aeronautics. *Air masses and fronts.* Washington, D. C. Government Printing Office. 28 copies.

Vetter, Ernest G. *Visibility unlimited.* New York, N. Y. William Morrow & Co. 4 copies.

SINGLE COPIES

Air navigation, part three: Dead reckoning and lines of position. New York, N. Y. McGraw-Hill Book Co., Inc. (Flight Preparation Training Series.)

Air navigation, part five: Relative movement. New York, N. Y. McGraw-Hill Book Co., Inc. (Flight Preparation Training Series.)

Air navigation, part six: Contact flying. New York, N. Y. McGraw-Hill Book Co., Inc. (Flight Preparation Training Series.)

Benstead, C. R. *The Weather eye.* London, England. Robert Hale Limited.

Blair, Thomas A. *Weather elements.* New York, N. Y. Prentice-Hall, Inc.

Brands, George J. *Meteorology.* New York, N. Y. McGraw-Hill Book Co., Inc.

Byers, Horace Robert. *General meteorology.* New York, N. Y. McGraw-Hill Book Co., Inc.

Elements of pre-flight aeronautics for high schools. New York, N. Y. The Macmillan Co. (Air Age Education Series)

Finch, Vernor C., and others. *Elementary meteorology.* New York, N. Y. McGraw-Hill Book Co., Inc.

Halpine, Charles Greham. *A Pilot's meteorology.* New York, N. Y. D. Van Nostrand Co., Inc.

Haynes, B. C. *Meteorology for pilots.* Washington, D. C. Government Printing Office. (U. S. Department of Commerce, Civil Aeronautics Bulletin No. 25.)

Jordanoff, Assen. *Jordanoff's illustrated aviation dictionary.* New York, N. Y. Harper & Brothers Publishers.

Jordanoff, Assen. *Safety in flight.* New York, N. Y. Funk & Wagnalls Co.

Map and aerial photograph reading. Harrisburg, Pa. The Military Service Publishing Co.

Moore, L. E., *Elementary avigation.* Boston, Mass. D. C. Heath & Co.

Naidich, James. *Air navigation made easy.* New York, N. Y. McGraw-Hill Book Co., Inc.

Petterssen, Sverre. *Introduction to meteorology.* New York, N. Y. McGraw-Hill Book Co., Inc.

Shields, Bert A. *Air pilot training.* New York, N. Y. McGraw-Hill Book Co., Inc.

Shields, Bert A. *Meteorology and air navigation.* New York, N. Y. McGraw-Hill Book Co., Inc.
Shields, Bert A. *Principles of air navigation.* New York, N. Y. McGraw-Hill Book Co., Inc.
Stewart, George R. *Storm.* New York, N. Y. Random House.
Taylor, George F. *Aeronautical meteorology.* New York, N. Y. Pitman Publishing Corporation.
*Thompson, Frederick B. *Practical air navigation.* Detroit, Mich. Thompson Aviation Publishers. (The Transport License Method, Practical Aviation Instruction.)
*Thompson, Frederick B. *Practical meteorology for airplane pilots.* Detroit, Mich. Thompson Aviation Publishers. (The Transport License Method, Practical Aviation Instruction.)
U. S. Army Air Corps. *Air navigation text.* Randolph Field, Texas. Randolph Field Printing Office.
U. S. Navy Department, Aviation Division: Office of Naval Operations. *Flying the weather.* Washington, D. C. Government Printing Office.
U. S. War Department. *Weather manual for pilots.* Washington, D. C. Government Printing Office.
Weems, P. V. H. *Air navigation.* New York, N. Y. McGraw-Hill Book Co., Inc.
Wenstrom, William Holmes. *Weather and the ocean of air.* Boston, Mass. Houghton Mifflin Co.

* These are books that were used when the course was being developed, but are referred to very little at present.

INDUSTRIES ASK FOR HIGHER TAXES

Business and industry are traditionally expected to be opposed to higher taxes. There came to our attention recently, however, an interesting full-page advertisement in the Appleton, Wisconsin, *Post Crescent* published in connection with American Education Week last November. Signed by 27 of the city's leading industrial firms, it cites the antiquity of the city's elementary-school buildings and reads in part:

"We feel that the children of Appleton are entitled to the very best educational facilities obtainable and it is with this object in view that Appleton's Industry takes time out to examine our grade-school buildings. . . .

"Industry is constantly building and adding new facilities to meet the greater demand for a higher standard of living. It then follows that education must be provided with modern tools and the very best teaching talent. . . .

"We strongly recommend to the Mayor, Common Council, and to the citizens of Appleton that the program of the Appleton Board of Education, which calls for the construction of five new grade schools over a period of fifteen years at a cost of $300,000 each be adopted now.

"We make this recommendation with the full realization that as large tax payers, we shall carry a substantial portion of the tax load if the program is adopted.

"We are proud of our city, our school administrators, and our teachers, and we want to be a part of this very timely and worthwhile educational program."

—*The Public and Education*

RATIONALITY AND EMOTIONALISM

JOHN BENJAMIN NICHOLS
Washington, D. C.

The past century and a half has witnessed stupendous advances in material technology, scientific achievement, and industrial production, resulting in the revolutionary introduction into everyday use of such marvels as the steam engine, rapid travel and distant communication, mass production, automobiles, moving pictures, aviation, electric and electronic appliances, radio, chemurgy, and a host of similar innovations. It is a commonplace observation that in the past sesquicentury there has been a vastly greater progress in the material and physical things of life than in thousands of years previously. This is not to say that there were no revolutionary innovations in past eras; there were such advances, of epochal importance, such as the invention of language, agriculture, use of fire, metallurgy, the wheel, navigation, architecture, gunpowder, printing. We must not underestimate the tremendous effect of such inventions in the progress of the human race from primitive savagery into advancing civilization. But these developments occurred at long intervals of time, centuries and millennia apart. The amazing feature in the material developments of the past sesquicentury has been not only their variety, volume, and character, but also in the breath-taking rapidity and tempo with which they have been introduced. Yet they are rapidly assimilated and utilized in our everyday life, and our sense of the marvels and possibilities of nature is dulled. The novelty of one year becomes the commonplace routine and instrument of the next, and contributes to the conveniences and welfare of the world.

These considerations apply to the material and physical things of existence. On the other hand, in the human, social, political, and economic fields of life there has been no corresponding advancement. Instead, there has been little effective social invention and engineering, and the result has been stagnation and lack of progress in these non-material aspects of life and society. There are great desiderata which through the ages man has sought to attain—freedom, equality, justice, humanitarianism, economic security, happiness, enlightenment. In the world of today, however, there is still social unrest, turmoil, frustration, violent political conflict, economic insecurity and want. Wars continue to recur at frequent intervals, constantly increasing in

deadliness and devastation, and attended with monstrous exhibitions of mass cruelty and atrocities on the part of supposed enlightened and civilized peoples. These facts show to how little an extent human aspirations for racial betterment and happiness have been realized, and what slight and inadequate social and civic progress has been achieved; even how little the race has really emerged from primitive savagery.

Even so far back as 1780 the astute Benjamin Franklin sensed the contrast between material and social advances, and made this prophetic utterance:

> "The Rapid Progress True Science now makes, occasions my regretting sometimes that I was born so soon. It is Impossible to imagine the Height to which may be carried, in a Thousand Years, the Power of Man over Matter. . . . O that Moral Science were in a fair way of improvement, that Men would cease to be Wolves to one another, and that Human Beings would at length learn what they now improperly call Humanity."

Mankind's activities and ways of life have been determined through a million years of evolution by powerful motivations firmly implanted in the inscrutable depths of human nature. These motivations are stubbornly fixed, conservative, relatively changeless, and an impediment to progress and improvement in the social setup of humanity.

There is, then, a vast contrast between the prodigious advances made in the physical and material things of life, and the stagnation and lack of progress in the social, civic, and economic fields of human affairs.

There are two psychic factors that are involved in the disparity of these two aspects of life, rationality and emotionalism, representing the two sides or poles of the mind, intellect and feeling.

Rationality or reason is an exclusive function of the intellect. It consists in the acquisition and coordination of knowledge (or of beliefs), and the exercise of intelligence and good judgment, entirely apart and free from the disturbing and distorting influence of emotion.

On the intellectual side of the mind we can differentiate two distinct methods by which beliefs are arrived at, which may be termed the speculative and the scientific methods.

The speculative method, by deduction, introspection, and hypothesis, erects elaborate structures of belief or philosophy on slight foundations of fact. In this method the processes are essentially subjective, deductive, and *a priori;* the mind works

from assumed cause to effect, from subjective thought into the objective world. This was the method of scholasticism. Great thinkers in all ages have thus formulated complete schemes covering whole departments of knowledge or the entire universe, and have taken such pride in these brilliant creations of their own intellects, and have regarded them as so complete and perfect, that observation of nature was regarded as superfluous and unnecessary.

The scientific method works in the opposite direction from the speculative. It is objective, inductive, *a posteriori* in character. It begins with a study of external phenomena, and, exercising a healthy skepticism, from them as a basis works out general laws. Rigidly suppressing preconceived notions and bias, this method by painstaking observation and investigation collects an adequate mass of objective data as a prerequisite to generalization.

The speculative approach to knowledge is illustrated by the attitude of the celebrated (and overestimated ?) seventeenth-century physician Thomas Sydenham. "It is my nature to think where others read," boasted he. But thinking is not the first element in scientific research. The scientific method was exemplified by John Hunter, a century later, in his advice to Jenner, when the latter began to ponder on the subject of vaccination against smallpox: "Do not think; investigate!"

Of the two methods, the speculative is far more attractive, and has a much stronger hold on human nature than the scientific method; it is the primitive and natural method of the untrained mind; it the more easily satisfies the innate thirst for knowledge. An insatiable curiosity is a dominant trait in human nature. Just as a superabundance of physical energy or "animal spirits" leads to exuberant physical activity, so does man's superabundance of mental energy lead to exuberant intellectual activity. The human mind confidently aspires to mastery and comprehension of the entire universe, and is reluctant to admit that anything is beyond its powers. Human nature is not satisfied with merely miscellaneous infomation, but demands a complete scheme of universal knowledge. It is impatient with gaps in knowledge, and is insistent for completeness, certainty, and finality. This eagerness for knowledge and impatience with the unknown is a powerful incitement to premature generalization and ill-founded assumption, and is a potent cause of error and fallacy. The insatiable thirst for knowledge as at-

tained by the attractive and dominant speculative method engendered the excesses of medieval scholasticism and sophistry, with their elaborate but vain and fantastic subtleties and philosophical rubbish. Uncritical theorizers can easily bring themselves to believe what they wish to believe ("wishful thinking"); scientists can believe only what the evidence permits or forces them to believe. The scientific method is tedious and laborious, and leaves many gaps in knowledge; it does not come naturally, but is a product of training, discipline, and culture.

The history of the world is a convincing demonstration of the inability of speculative methods, and of the competency of scientific investigation, to produce effective knowledge. For thousands of years, during the ancient and middle ages, the world was stagnant, on account of its ideology being dominated by authority and by speculative methods of thought; but with the transition into modern scientific attitudes and technics has come a tumultuous accession of prodigious material progress. In the intellectual world the Renaissance, or the transition from the medieval period to the modern era, has been accomplished by the introduction of scientific method. In different fields this has taken place at different times; and it is possible that, without our realizing it, in some realms of knowledge the Renaissance has not even yet occurred. Like an atomic bomb, the introduction of the scientific method seems to unlock the mind and release tremendous mental energies.

The history of medicine is one example of the comparative efficacy of the two methods of approaching knowledge. For thousands of years medicine was completely under the influence of speculative methods; and the sterility, stagnation, and inefficiency of medicine during that long period is a convincing proof of the futility of those methods. On the contrary, within the brief span of the past sesquicentury, solely by the employment of the scientific method, medicine has undergone a wonderful transformation and made stupendous advances. Other fields of thought have followed a parallel course.

Unfortunately the emotional side of the mind is apt to interfere with the proper working of the intellect, and disturbing influences are brought into action which pervert the judgment and lead into error the conclusions arrived at.

Now *emotion* is just as essential and important a factor in the operation of the mind as is the *intellect*. Emotion is the dynamic power and motive force that impels men to action and initiates

and maintains human activities; while reason, or the intellect, is the guiding principle. We may consider the analogy of the automobile. The fuel propels the vehicle, while the steering gear guides it. Either is helpless without the other; the driver at the wheel cannot move without the action of the motor; while propulsion without guidance will land the car in the ditch. Emotion is what moves man, and reason guides him.

It is emotion that vivifies and enlivens life. It is the seat of happiness, of aspiration and ambition, of inspiration. Emotionalism is the heart of religion, the vehicle of enthusiasm. Pure intellect is cold and hard, unfeeling, impersonal, indifferent; emotion is warm, and intimate, and animated. Intellect is a matter of the head; emotion enlists the heart.

But undisciplined emotion is apt to run wild and go out of control, thus interfering with the wise guidance of reason, and wrecking the machine. Ignorance and error, credulity, intolerance, prejudice and bias, excitement and passion, hatreds and loves, self-interest,—factors such as these disturb the intellectual processes and lead to falsity and error. Wishful thinking, the effort to attain beliefs which one desires to believe, is a fruitful source of error. People entertaining unfounded or doubtful beliefs attempt to justify or prove them by appeals to reason,—"rationalization" as it is called,—by specious and labored reasoning, with fallacious and unconvincing results. The insatiable thirst for knowledge which is a dominant trait in human nature also heads to hasty and superficial generalizations, through the use of the inferior subjective methods of thought.

Since humanity is motivated and activated through emotional factors, the course of society and history will be strongly influenced by the character and validity of the emotional elements. If the basic factors are correct and well founded, progress will result; if they are unsound and unwise, there will be stagnation or retrogression. Irrational and unruly emotionalism, false though firmly held notions, deeply planted prejudices, economic pressure, mob hysteria and passion, cannot produce substantial progress; yet these are dominant elements in human nature and exert a major influence on the course of human affairs, for good or bad. Without the corrective guidance of reason and wisdom the social machine goes into the ditch. The faulty and misleading emotional factors are so firmly implanted in human nature and are so discordant that the ability to achieve social betterment seems to be almost impossible and hopeless, and the difficulties

insuperable; this in contrast with the amazing advances which the world, guided by unemotional rationality, is making in material things.

Items of fact and knowledge elicited by pure intellectual and scientific processes are not apt to arouse any disturbing emotions,—unless or until they may be projected into emotional fields and encounter personal prejudices and interests, social, political, religious. When, after a period of initial research and discussion, a fact of nature is established as firmly as is possible to the human understanding, it is unanimously accepted by the scientific world and solidly incorporated in the vast body of accumulated and established knowledge, not subject to further question or feeling. Scientific discoveries, especially in their "pure" or initial stages, are usually too abstract and remote from everyday affairs to arouse emotional feeling. There is nothing to get excited about in cold scientific facts which do not touch our intimate lives and feelings. A new discovery may arouse languid interest, but also be a matter of academic indifference. What do we care, what is it to us, if another specimen of prehistoric man is found, if the composition of a complex chemical is worked out, if a new comet is discovered in the heavens?

So, the disparity between the remarkable material and scientific advances which have taken place in modern times and the stagnation and lack of progress in social and human fields for thousands of years is explained. The great advances have occurred in the fields of pure intellect and reason where emotional disturbances and influences have been absent, or negligible, or disciplined. But in the social (non-material) affairs of life inferior methods of seeking knowledge, emotional disturbances, and conflicts of interests and feelings have retarded progress. Reason and wisdom, activated by enlightened emotion, promote advancement; irrational, unbridled, and misguided emotionalism impedes it. Human nature being what it is, the outlook for social betterment is not promising.

Whatever may be set forth as the higher aims of adequate education and training for life,—vocational competence, social and civic efficiency, ethical conduct, culture, character,—there are certain fundamental teachings which are essential and applicable to all these aspects of life. Among these are the humble three R's, which are indispensable tools for human activities. Another discipline necessary for high intellectual attainment is the cultivation of the optimum technic for acquiring knowledge,

—that is, through pure rationality. There can be no more important or fundamental aim in the educational scheme than the thorough inculcation of the scientific method and attitude of mind, the use of the objective approach to knowledge. This will implement the exercise of reason, intelligence, wisdom, good judgment in human affairs, and will produce the most efficient technics and methods for conducting the activities of life. With the exercise of rationality must be conjoined rigid control of emotional factors so as to eliminate the distorting and misleading influences which these can introduce. It may be noted that the scientific discipline is highly vocational: in a sense science is knowing, not what is known; means, and not the end; method, and not subject matter. It is the best tool for producing factual and effective knowledge in any field; it is of universal and fundamental utility to that end and to the service of mankind. Thorough training in unemotional rationality, so that it becomes an instinctive habit of the mind, is imperative in superior education.

IRON POWDER USED IN WAR TO IMPROVE RADIO AND TELEVISION RECEPTION

Improved radio and television reception in post-war civilian sets is promised by an iron powder which was first made in this country in 1941, General Aniline and Film Corporation said, revealing that carbonyl iron powder is now being specified by design engineers for use in civilian electrical radio, television and electronics equipment. The company disclosed that during the war this product was considered so critical that reserve equipment was installed and is now available for the anticipated increase in civilian needs domestically and for export.

The Grasselli, N. J., plant is producing carbonyl iron powder in sufficient quantities to meet all civilian demands. The unusual magnetic and electrical properties of carbonyl iron powder make it ideal for use in manufacturing electro magnetic devices. Its use will permit forthcoming radio sets, both FM and AM, to give higher performance, especially improved tone quality and will make possible sharper tuning. It will also provide a sharper television image. Throughout the war carbonyl iron powders were used in making radio equipment for planes, tanks, and ships, as well as in radar and various secret electronics devices.

The company revealed also that carbonyl iron powder is now being shipped to various European countries which are engaged in modernization programs and in rebuilding their bombed and wrecked communications systems.

EXPRESS TO THE MOON

There are 200,000 miles of railroads, 58,000 miles of airways, 12,000 miles of steamship routes and 16,000 miles of motor routes available to shippers using Railway Express Service which if totaled together would exceed the distance to the Moon by 48,000 miles!

NOTES FROM A MATHEMATICS CLASSROOM

JOSEPH A. NYBERG
Hyde Park High School, Chicago

116. Transposition. The abolition of transposition would eliminate many errors according to some writers. Perhaps I should say "according to many writers" since it is almost impossible to read an article on the teaching of algebra without finding some reference to pupils who solve $2x=10$ by writing $x=8$ because they were taught transposition. The main argument for the elimination of transposition is about as follows: If a pupil is taught to solve equations by using only addition, subtraction, multiplication, and division, then the pupil will remember that $2x=10$ is solved by undoing the multiplication, and $3+y=12$ is solved by undoing the addition; hence the pupil will not write $x=8$.

But what is to prevent the pupil from thinking "since $2x=10$ means that 2 is added to 10, I shall subtract 2 from each member," and "since $3+y=12$ means that y is multiplied by 3, I shall divide both sides by 3?" In other words, what assurance have we that the pupil will recognize what operation he is to use? My contention is that if the pupil can recognize the correct operation, then he will use transposition correctly (unless we assume that a pupil can learn to handle only *four* operations, and that a *fifth* one is the straw that breaks the camel's back).

Granting that *four* operations is the limit of the pupil's capacity I would like an answer to the questions: How is it possible to avoid transposing? What means can be used in class to prevent a pupil from using transposition? I will not be satisfied with an answer like, "Oh, we use it but we don't introduce it early," or, "Of course you can't avoid it eventually but we don't use it at the start." Such answers are unsatisfactory. To such answers the obvious reply is, "But the articles to which I refer (which imply that $2x=10$ is solved incorrectly because the pupils were allowed to learn about transposition) should then admit that the pupils make this error *in spite of* any use or non-use of transposition, and should admit that the trouble is elsewhere. We cannot simultaneously blame transposition and admit that it is introduced only after the pupil understands the process. How can a teacher avoid transposition?

My own experiences, and I think they are typical, are about as follows: We learn to solve $x+3=10$ by adding -3 to both

members (reversing the addition); we solve $4y=40$ by dividing 40 by 4 (reversing the multiplication); and we solve $6r-5=13$ by first adding 5 to both members. About the third day some pupil, when reciting at the board, says, "The -5 there is a $+5$ here," or, "Rub out the -5 and put a $+5$ on the other side," or, "You can do it easier if you just erase the -5 here and write $+5$ here," or "We know that the -5 here is the same as $+5$ there." In this way the operation is revealed to the class, and the corrupting influence begins. How can a teacher prevent some pupil from letting the cat out of the bag?

It may be charged that the trouble is the textbook, that a pupil may never hear of transposition in the class but may read about in the textbook. I doubt if this is a good answer. Few pupils read any explanation in the text unless they are told to do so; and this reading is more likely to be done by the brighter pupils than by the duller ones. It is the lazy pupil who introduces "the -5 here is a $+5$ here"; the bright pupil usually wishes to curry favor with his teacher by using the teacher's methods even after he has discovered a shorter method. I have also tried the experiment of not using the textbook, of making no assignments from any book, and of writing even the practice material on the blackboard, and so forth. The results were the same; inevitably some pupil would say, "You can erase this -5 here and write $+5$ here." In desperation I finally tried the experiment of not allowing any pupil to explain any equation at the board or even writing any solution at the board. I explained each equation myself, and then let each pupil work at his seat. But as I walked around the room to help the slow workers, I found that they were crossing out the -5 on one side and inserting $+5$ on the other. When asked for an explanation, the answer with slight variations, was, "Well, you can see the -5 here becomes a $+5$ here." How can transposition be avoided?

117. Meaning, Thinking, and Drill. What has been said about transposition applies also to cancellation. Regardless of how carefully the teacher avoids the use of that word and insists on having the pupil talk about dividing the numerator and denominator, some pupils will draw a line through the common factors and also through some of the common terms. When the pupil cancels some common terms, he thinks that he is dividing. If he is intelligent enough to distinguish between dividing and subtracting he is intelligent enough to use cancellation correctly;

and if he cancels incorrectly, it is unlikely that he can distinguish between dividing and subtracting. Those who argue against transposition and cancellation assume that *thinking* will eliminate errors, and that *meaning* is a substitute for old fashioned *drill*.

There are situations, however, in which success depends on the ability to eliminate thinking, situations in which thinking is detrimental to success. Consider the driving of an automobile. You depress the clutch, and push the starter; you release the clutch, and move; you depress the clutch, and move a lever; you release the clutch, and so forth (assuming you are driving a fairly old model). Surely no driver can be considered competent or successful until he has learned to do all this *without thinking*. The driver should be able to carry on a conversation while doing all this, or able to think about some other matters. Similar situations are numerous. After learning the how, and why, and wherefor of something, we must repeat the performance often enough to make the operation mechanical; that is, we must be able to do certain things without thinking.

If transposition is undesirable, then also we should never use the theorem about the base angles of an isosceles triangle. Each time that we meet such a triangle we should bisect the vertex angle and prove two triangles congruent. Likewise, we should never use the theorem that states that the opposite sides of a parallelogram are equal, but should draw a diagonal and once more prove two triangles congruent. In the geometry class we teach the value of generalizations which replace thinking on one level of intelligence with thinking on a slightly higher level. The fact that an automobile occasionally develops faults should not make us go back to ox carts.

118. Interference Bonds. There are bonds that tie various ideas together, and there are bonds that act in an opposite manner. The only text that says much about the second variety is Thorndike's *Psychology of Algebra*. Although it was published in 1923, it should be required reading for every prospective teacher of algebra.

The addition of fractions is a simple example. A pupil fresh from grammar school or in the first months of algebra does not discard denominators when adding fractions. He may get $\frac{2}{5}$ when adding $\frac{1}{2}$ and $\frac{1}{3}$ but he does not get $3+2$ or 5 for the sum. But after he has solved a few equations with fractional coefficients and has seen the denominators disappear, then the

sum of $\frac{1}{2}$ and $\frac{1}{3}$ suddenly becomes 5. What he has learned about solving equations *interferes* with his skill with ordinary fractions. The new ideas interfere with ideas that were once well established. This is so well recognized that many teachers refuse to allow a pupil to speak of "clearing of fractions." If our language had a single word for this phrase, it would be tabooed as much as the word transposition.

The square root of a^2+b^2 is particularly annoying. Does not *plus* mean *and*, and is he not asked to find the square root of both a^2 *and* b^2? When you divide numerator and denominator of a fraction, do you not divide *both* numberator *and* denominator. To find the square root of 16/9 do you not find the square root of *both* 16 *and* 9?

Does not $x+3$ mean the sum of x and 3? Has anyone ever seen a teacher actually add 3 to x? Don't answer by saying that it is impossible; the pupil has often seen the teacher do the impossible as, for example, when finding 10% of an unknown number.

When asked to divide 5 by $\sqrt{3}$, does the teacher actually *divide* 5 by $\sqrt{3}$? Decidedly not; the teacher begins by *multiplying* by $\sqrt{3}$.

To find the height of a tree it seems sensible to stretch a rope from the top to the bottom, but if you did so you would be marked a failure in the trigonometry class.

To find how much gasoline you have in the tank of your car do you empty the tank and pour the gasoline into gallon containers, or do you look at a gadget on the dashboard?

If a mathematician wished to raise oats in a certain field, he should not really plant oats in that field. He ought to plant rye in some distant field, and harvest the corn that nobody planted in a third field. Thus he would get the necessary fodder for his horses, which was what he really wanted.

This may sound stupid to a teacher, but it is a fair sample of what a pupil thinks when confronted with $2x=10$ (after having been away from algebra for a while). He may be thinking, "x should be 5, but that is very likely the wrong answer. In mathematics few things are what they seem to be; you seldom do what you expect to do. I had better guess 8 or 12 for the answer." And the only remedy for this condition is: Thinking plus drill plus review plus thinking plus drill plus review, and so forth.

EASTERN ASSOCIATION OF PHYSICS TEACHERS

ONE HUNDRED SIXTIETH MEETING

Simmons College
300 The Fenway, Boston, Massachusetts
Saturday, December 8, 1945

Joint Session with
The New England Biological Association
and
The New England Association of Chemistry Teachers

MORNING PROGRAM

9:30 Meeting of the Executive Committee.
9:45 Greetings: Dr. Bancroft Beatley, President of Simmons College.
10:00 Address: "Polarized Light in Physics, Chemistry, and Biology," Mr. Edgar Barr, of the Polaroid Corporation, Cambridge, Massachusetts.
10:45 Address: "New Goals in School Health Programs," Prof. Curtis M. Hilliard, Head of the Biology Department, Simmons College.
11:30 Address: "Textile Research Looks Ahead," Prof. Edward R. Schwarz, Head of the Textile Division, Massachusetts Institute of Technology.
12:30 Luncheon

AFTERNOON PROGRAM

1:30 "Description and Demonstration of Surplus Property Electronic Equipment Available for Schools," Prof. L. B. Arbuimbau, Massachusetts Institute of Technology.
2:15 Business Meeting
2:30 Address: "Electronic Theory of Acids and Bases," Prof. William F. Luder, Chemistry Department, Northeastern University.

BUSINESS MEETING

The following were elected officers for 1945–46:
President: John T. Gibbons, Brighton High School, Brighton, Mass.
Vice-President: Albert Thorndike, Milton Academy, Milton, Mass.
Secretary: Carl W. Staples, Chelsea High School, Chelsea, Mass.
Treasurer: Albert R. Clish, Belmont High School, Belmont, Mass.
Executive Committee:
George H. Colman, Gloucester High School, Gloucester, Mass.
James J. Cotter, Chelsea High School, Chelsea, Mass.
Edwin Sawin, High School, Cranston, R. I.

The following were elected active members:
Wilmot S. Babcock, Williston Academy, Easthampton, Mass.
John R. Gow, Westminster School, Simsbury, Conn.
Frank H. Todd, Bangor High School, Bangor, Maine
Sister Margaret Clare, Emmanuel College, Boston, Mass.
Sister M. Bernarda Murphy, Regis College, Weston, Mass.
Robert W. Card, Winchester High School, Winchester, Mass.
John H. Crowell, Braintree High School, Braintree, Mass.
Edgar N. Sanford, Westover School, Middlebury, Conn.

It was unanimously voted that it was the sense of the meeting (a) that 1% of surplus war material, suitable for school purposes, should be made available to schools at a nominal cost;

(b) it has been estimated that 1% of the total surplus of electronic, physical, biological, and chemica equipment would meet the problem of present-day school needs as proper adjuncts to instruction;

(c) that schools in the past have had a negligible amount of this equipment and so obtaining surplus war materials for the schools would not affect the market, for normally a vast majority of the schools would not purchase it.

In view of the above, each organization was requested to write the several Congressmen from New England setting forth the facts itemized above, and inquiring how surplus material could be obtained by schools with a minimum amount of red tape and in the most expeditious way.

NEW GOALS IN SCHOOL HEALTH PROGRAMS

Abstract of address by PROFESSOR CURTIS M. HILLIARD

Professor Hilliard spoke on the importance of a definite health program in the schools. He mentioned a report of the Committee on Reorganization of Secondary Education in 1918 which listed 7 objectives to be worked for. The first of these was health, but this, he said was not the primary objective in many school programs, some not appreciating its prime importance.

He said there must be a plan first, and second that this plan should be supported by top management, committees, superintendents, principles, nurses, and teachers of physics, chemistry, biology, and other science subjects. The first objective should be healthful school conditions. Often a school starts with an excellent plant, but it needs watching lest it deteriorate. Second, there should be instruction in personal hygiene and public health. State laws require instruction regarding effects of alcohol and narcotic drugs, and tuberculosis, but why limit it to these?

There should be teachers qualified to teach personal hygiene, but teachers colleges do not prepare teachers adequately to teach this. They should change the curriculum to include these subjects or provide state educators to assist teachers in arranging material for health education. While physical education is pretty well provided for, health and hygiene are usually reserved for rainy days. Health protection and preservation, as well as mental hygiene should be objectives.

The continuing prevalence of diphtheria was mentioned and the need for enforcing school vaccination laws. Laxity in this respect causes outbreaks. Massachusetts has had no smallpox for twelve years, but over 100 diphtheria cases. Two towns were cited where boards of health refused to provide clinics for control of diphtheria, in one of which cases the school board took the matter into its own hands.

Upper respiratory infections, as common colds, measles, chickenpox, German measles, mumps, flu, and infantile paralysis are the most prevalent in schools, and are prevented by (1) active immunization, and (2) environmental control, as in typhoid, dysenteries, etc. No great progress has been made in many of these epidemic diseases, which epidemics coin

cide with the school year, one factor probably being the bringing together of children offering better contacts.

Starting with the old superstition of miasma it seemed when germs were discovered that air must be the medium through which diseases spread. An era of fumigation, pest-houses, etc., followed with the idea of distance.

Pfluger and others by experiments indicated that microbes leaving the mouth traveled only 2 or 3 feet, then followed a trajectory to the ground. Droplet infection was deemed not so important and contact infection was considered more likely.

In 1936, Wells, with a machine for analyzing the bacteria in air, made quite accurate quantitative and qualitative tests, which led to reappraisal of the role of the atmosphere. Some if not much of the upper respiratory diseases were believed transferred by air to remote distances. Small particles, of 10 to 15μ diameter do not reach a surface before evaporation. Results of some of these analyses were given.

Larger cities showed more bacteria per cubic foot of air. Quiet air contained relatively few. Sneezing increased the number greatly, but when the sneeze was shielded by a handkerchief the number was very much smaller. In speaking certain letters as p, t, f, an appreciable ejection of saliva containing bacteria was found. The velocity of air 2 inches from the mouth was 152 feet per second, almost that of a rifle bullet. Bacteria remain suspended in the air for some time. Viruses are not so easy of detection. These experiments gave evidence of air-borne infection, and if the density concentration is sufficient, pupils may inhale an infectious dose of bacteria from the air in the course of the morning in the school-room.

Psitticosis was found to be air-borne in specific cases.

Disinfection of air reduces danger of infection. Methods of preventing infections are by (1) excluding organisms from the air by covering the face when sneezing, (2) diluting the air by air replacements. The best ventilation does not, however, give sufficient air-change to dilute the air sufficiently, (3) dust control, by oiling floors, etc., (4) physical or chemical disinfection of the atmosphere. Ultraviolet burns the skin. One must rely on irradiation of air, or curtains of light as used in operating rooms, or for separation of infectious diseases in wards. Chemical mists were found effective.

The recent use of fluorine in dental caries was mentioned.

TEXTILE RESEARCH LOOKS AHEAD

Abstract of address by PROFESSOR EDWARD R. SCHWARZ

Laboratory walls between biology, chemistry, and physics disappear in textile research although there is more of physics.

In the past too much time was spent in measuring strength of textiles by crude methods. Devices now are tensile machines, but they stress time. The load is applied at constant rate in pounds per minute, and electronic devices have been linked up with them. In the past samples were used to

measure the characteristics of the testing machines but now the reverse is true.

For forty years the structure of fibres have been tested by twist. By placing the fibres between two rotating jaws it was believed that twist could be removed and inserted. It is now known that this can be done with out rotation.

As to size fibres are extremely small in two dimensions and short in the third. New machines arrange the fibres in a sample in a frequency array from long to short fibres, determining at the same time modal, average, or median, quartile or percentile, fibre length and effective staple.

In controlling evenness, samples formerly were wound on a panel. Now a photo-cell arrangement is used with an ammeter or galvanometer in a device which plots the frequency distribution of thick and thin portions. There is a cabinet of 8 vacuum tubes, and a photoelectric potentiometer. The thread sample is tied in, passes over two spools and out, the machine registering automatically.

Changes of strength are found in a fibre-tester. Formerly the grams strength was read, but this showed nothing of what happened up to rupture. The result of microorganisms such as fungi on the fibre can now be measured.

Permeability of a fabric to air is now tested giving the cubic feet of air per minute per square foot. Heat transmission is also measured.

In wearing out tests there have been about 32 semicommercial or commercial machines on the market, but something which can be interpreted afterwards is not so easy. It is impossible exactly to duplicate service conditions in the laboratory, but a similar result can be produced.

Other things which can be tested are:

Flexibility.

Draping quality, (not dependent on flexibility).

Projection of samples in micro-reading equipment for closer study of structure.

Stereoscopic binocular and ordinary microscope tests.

Electron microscope technique applied to fibres and fabrics, in which photos of the fibres or fabric are made from impressions in plastics.

Cross-sections of fibres are made by histological methods, embedding, cutting, etc., and photomicrography. Histology has become important in finding out what types of fibres are best under given conditions. Slides of various sections of natural and artificial fibres were shown, as well as bubble fabrics (blown up with nitrogen), effect of fungi, stereoscopic pictures, and pictures made with ultraviolet and polarized light to bring out the structures better.

Use of X-ray shadowgraphs, the X-ray diffraction camera, improvements in the Mullen tester, and Edgerton flash-photography as applied to textiles were mentioned.

WAR-SURPLUS ELECTRONICS EQUIPMENT

L. B. ARGUIMBAU, *Massachusetts Institute of Technology*

At the beginning of the war, college radio laboratories were on the average very poorly equipped. Many of the instruments in active use had been obsolete for ten or twenty years. The need for trained military personnel made a rapid change necessary and the government ESMWT program made modern equipment available in substantial quantity. The changes that have taken place during the war in the radio field have been so startling that much of this equipment is already obsolete and we hope to replace it from government surpluses.

A superficial survey of high school science laboratories indicates that the high school problem is even more serious than that in the colleges.

Although it is difficult to get accurate figures on the amount of the electronics equipment which is likely to appear as a government surplus, it seems probable that there will be between three and five billion dollars worth. Unless positive action is taken it seems doubtful that any large portion of this will ever be put to appropriate use. This equipment, paid for and owned by the public, amounts to something like $1,000 per high school and college *pupil* for the country as a whole. If we are extraordinarily modest and suggest that 1 per cent of the material be turned back to the public for educational purposes, a high school with 1,000 pupils would receive $10,000 worth of equipment. There has been some talk of granting the schools up to 30 per cent of the total rather than a mere 1 per cent but so far the actual progress has been disappointing.

A group of us at M. I. T., in an effort to obtain information for the Office of Education sent out a questionnaire to various high schools in eastern Massachusetts. On the basis of twenty-four replies a list of equipment has been prepared which we consider suitable for a school of perhaps 1,000 pupils. The material in the list adds to a total new-purchase price of around $3,000. If such a proposed list were followed on a nation-wide scale, the stock pile would be barely scratched but the effect on the high school laboratories would be very great.

In addition to a large stock of batteries, meters, resistors, and other routine items the list includes audio oscillators, recording and public-address equipment, and a three-inch cathode-ray oscilloscope. A second list of a few pieces of more elaborate equipment has been made. It is believed that one or more sets of each type will meet the requirements of a school of almost any size.

It may be useful to illustrate the advantage of such equipment by a concrete example—that of sound measurements. As you know, it has been difficult to give students any accurate idea of pitch except by tuning forks. On the other hand, large numbers of loud speakers and audio oscillators are included in the war surplus. These make it possible to generate sounds of any calibrated pitch desired and to study the sensitivity of the ear.

Most of the textbooks show pictures of sensitive-flame and rotating-mirror devices for making speech wave forms visible. These are fussy to use, do not give good results, and are totally unrepresentative of present-day methods. Good cathode-ray demonstration equipment for making wave forms visible has been available for the last twenty years but for the most part high schools have not felt that it came within their budgets. Cathode-ray oscilloscopes are now available in such quantity that there is no excuse why every high school in the country should not have at least one.

Laboratory manuals for the last fifty years have outlined an experiment to measure sound velocity by means of a tuning fork and a variable length resonator. If we are honest, we must admit that few, if any, of us understand the detailed mechanism by which such resonance takes place. How many of us understand why we should make a correction equal to a quarter of a tube diameter? By means of a fixed-length air column and an exploring microphone, it is possible to make the measurements without any corrections and without any complicated arguments about the properties of an open-ended pipe. Modern equipment should encourage the better students to do some independent work; above all, it should awaken interest.

It is important that science teaching be kept closely in touch with the progress of the world. There are many more loud speakers around us today than there are tuning forks. If proper use is made of a small portion of our surplus equipment, laboratories can be made more interesting and instructive.

On November 8, 1945, the Surplus Property Administration made public Regulation No. 14 intended to handle the educational needs of the country for surplus equipment. Among other things, it contains the following provisions:

"8a . . . Any nonprofit institution . . . shall be entitled to acquire . . . any surplus property available for disposal, at the fair value of such property and in lots not smaller than the smallest lots consistent with commercial practice . . . ."

"9a . . . The fair value . . . shall be the same value as established for disposal to government agencies . . . and shall not be greater than the lowest price which is offered to any trade level . . . ."

"9b . . . a discount of 40 per cent upon orders by or for educational institutions" shall be allowed on approved applications.

In the writer's opinion, these provisions are hopelessly inadequate. In the first place schools must purchase a dollars worth of this and fifty cents worth of that. The list prepared by the group at the Massachusetts Institute of Technology adds up to perhaps $3,000 worth of equipment (at new prices) but it is composed of a large number of items in noncommercial quantities. The SPA requirement can only be met by group purchasing on a kit basis. The need for such a setup must be recognized. Secondly, and more important, school budgets have no provision for the purchase of

equipment in the amounts that public interest demands. If the schools are to get this equipment, the Congress must make proper bookkeeping adjustments to transfer ownership of an appropriate amount of it from the military branch of our government to the educational. Whether this is done by lowering the charges to a truly "nominal amount" or by appropriating a sum of money to the schools for the purpose, is not important. To this end the writer recommends that the Congress, (1) provide ways and means for the distribution of surplus electronic equipment to nonprofit educational institutions, and (2) that such institutions shall be entitled to receive equipment having a purchase price equal to $10.00 per student in the ninth grade or above, such limit not to be less than $3,000.

Similar provisions must be made in all fields where surpluses develop.

The Office of Education has made very strong efforts toward getting the material to the schools. Recently it has received support, but more is necessary. It is to be hoped that teachers will make their needs known to their Congressional representatives so that our war surplus can be put to the maximum possible public good.

APPENDIX

The lists below represent the needs of typical high schools for electronics equipment. The first kit is suitable for small schools. Combinations of one or more kits of the first type with one or more of the second should meet the needs of almost all large high schools and vocational schools.

It should be emphasized that the list is not at all official. It represents the opinions of a group at MIT based on a questionnaire sent to about 30 Massachusetts schools. Suggestions and comments would be very much welcomed.

KIT I. Basic Kit Suggested for Small High Schools.

Wire and cable	4000′ assorted wire for laboratory leads and circuit wiring, 3 lb. assorted enameled copper wire sizes 10–30 B and S, 250′ No. 12 nichrome wire.
Motors—ac	1-1/30 hp, 1-$\frac{1}{3}$ hp, 2-$\frac{1}{4}$ hp.
Fuses	100 assorted.
Batteries	40 No. 6 dry cells, 2 storage batteries.
Vacuum tubes	100 receiving, 10 transmitting.
Condensers	35 assorted air condensers, 150 assorted fixed condensers (100 $\mu\mu$f–0.1 μf), 24 electrolytic condensers.

Resistors	500 assorted 2w fixed 200 ohm-1 Megohm, 20 rheostats and potentiometers, 1 decade resistor.
Transformers	6 power transformers, 8 audio transformers, 20 assorted IF transformers.
Chokes	6 for power-supply filters, 20 radio frequency.
Variac	3
Mounting components	12 chassis, 60 tube sockets, 35 assorted dials and knobs, 46 porcelain insulators, 50 mounting strips, 200 lugs, 10 lb. solder.
Connecting and interrupting components	47 assorted switches, 200 clips, 200 spade lugs, 50 plugs, 50 jacks, 300 binding posts.
Converters	5 loudspeakers, 2 microphones, 4 headphones.
Radio communications equipment	1 HF oscillator (or transmitter) 20 watts CW.
Sound equipment	1 public address system, 1 recorder and playback.
Meters	7 milliammeters, 3 ammeters, 4 voltmeters, 1 ohmmeter, 1 wattmeter, 1 illumination meter, 1 watthourmeter.
Radio and radar test equipment	2 audio oscillators, 1 RF signal generator, 1 3″ oscilloscope.
Frequency meas. equipment	1 wavemeter, 1 frequency meter.

Power supplies	1 rectifier type (300v, 100 μa).
Voltage, amperage, and resistance meas. equipment	1 tube tester, 1 voltohymst, Jr.
Tools	12 pliers, 6 cutting pliers, 2 hacksaws, 1 hand brace, 1 micrometer, 15 screwdrivers, 1 socket hole cutter, 4 soldering irons, 1 tin shears, 1 calipers, 4 hammers, 2 wire gauges, 2 vises, 4 files, 4 "C" clamps, 1 hydrometer.
Miscellaneous equipment	1 battery charger, 6 telegraph keys and sounders, 2 relays, 4 crystals and holders, 12 crystal detectors, 15 neon lamps.

KIT II. Supplementary Kit for Large High Schools.

Generators	1 low power, 400–800 ~.
Motors	1 ½ hp ac, 1 1 hp ac.
Radio comm. equipment	1 walkie-talkie, 1 comm. receiver, 1 transmitter (200 w)
Tubes	2 8005, 2 magnetrons, 2 reflex velocity—modulated tubes.
Subassemblies	1 FM adaptor.
Meters	1 microammeter.
Test equipment	1 5″ CR oscilloscope and spare tube.
Meas. equipment	1 VTVM.
Electronic speed regulating and meas. equipment	1 strobotac

Miscellaneous equipment	1 dynamic demonstrator, 1 motion picture projector (sound), 1 tap and die set, 1 socket wrench set, 1 electric bench drill. 1 television transmitter receiver.*

* Suggested as appropriate for groups of schools.

ELECTRONIC THEORY OF ACIDS AND BASES

Professor William F. Luder gave a discussion of the various theories of acids and bases with especial reference to the five theories at present under consideration.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should obser e the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solution are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1947. *Walter R. Warne, Columbia, Mo.; Mina Rutherford, Gananogue, Canada and Grace Ansley, Clifton Springs, N. Y.*

1957. *Proposed by Howard D. Grossman, New York.*

Find the length of the longest ladder that can be carried, parallel to the ground, around the corner of a corridor, where "a" is the width of one arm of the corridor and "b" is the width of the other.

Solution by Isadore Gosz, West De Pere, Wis.

Let RST be the longest ladder. RST will be the shortest line which will connect any points R and T on the outside walls and pass through the corner point S. Let L be the length of the ladder.

$$L=RS+ST=b\csc\theta+a\sec\theta.$$

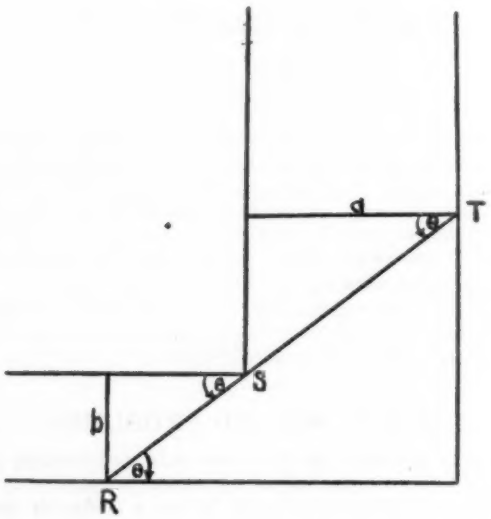
$$\frac{dL}{d\theta}=-b\cot\theta\csc\theta+a\sec\theta\tan\theta=0$$

$$a\frac{\sin\theta}{\cos^2\theta}=b\frac{\cos\theta}{\sin^2\theta};\qquad \tan^3\theta=\frac{b}{a}$$

$$\sec\theta=\frac{\sqrt{a^{2/3}+b^{2/3}}}{a^{1/3}};\qquad \csc\theta=\frac{\sqrt{b^{2/3}+a^{2/3}}}{b^{1/3}}$$

$$L=\frac{b\sqrt{b^{2/3}+a^{2/3}}}{b^{1/3}}+\frac{a\sqrt{a^{2/3}+b^{2/3}}}{a^{1/3}}$$

$$=(a^{2/3}+b^{2/3})^{3/2}.$$



Solutions were also offered by Hugo Brandt, Chicago; Julius S. Miller, Los Angeles, Calif.; U. Struyk, Paterson, N. J.; F. R. Miksa, Aurora, Ill.; Paul Mount-Campbell, N. Mex. Military Institute; V. H. Paquet, Tigard, Ore.; V. C. Bailey, Delaware, Ohio; Wm. A. Richards, Berwyn, Ill.; Helen Scott, Baltimore, Md.; M. Kirk, Media, Pa.; Brother Philip, Montreal, Canada.

Note on 1957. V. H. Paquet in his solution states, "From investigation of the triangles between extension of ladder sides, ends of ladder, and the corridor sides (shown to larger scale), and assuming that ladder ends are straight lines at right angles to ladder length, it is found that a reduction of at least 2.1 times the depth of the ladder sides is required if ladder is to clear.

Therefore net $L_2=(b^{2/3}+a^{2/3})^{3/2}-2.1w$.

As b increases and a increases, so does the necessary deduction increase.

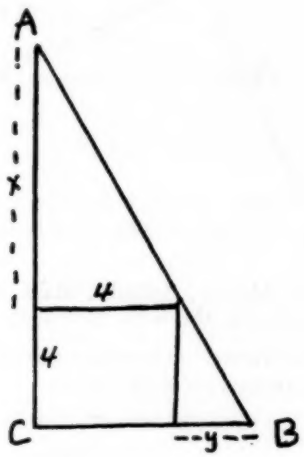
2.1 corresponds to the reduction when $b=4$ and $a=12$."

1958. *Proposed by F. A. Bjorkland, San Diego, Calif.*

In right triangle ABC a square $CFDK$ is inscribed with D on the hypotenuse AB. If each side of the square is 4, construct AB so that $AB=15$.

Solution by M. Kirk, Media, Pa.

From the figure, using similar triangles, and the right triangle these equations are easily derived:



$$xy=16$$

$$(x+y)^2+(y+4)^2=225.$$

Since the solution of these equations, involves only the quadratic, the root can be found. When x is determined, or y, the construction is easily made.

Solutions were also offered by Helen M. Scott, Baltimore, Md.; Hugo Brandt, Chicago; and V. H. Paquet, Tigard, Ore.

1960. *Proposed by Brother Felix John, Philadelphia, Pa.*

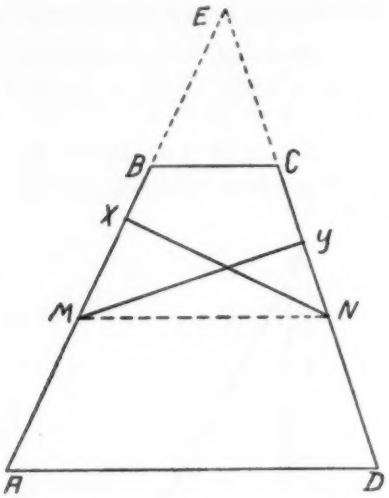
Given M and N, the midpoints of the non parallel sides AB and CD respectively of the trapezoid $ABCD$. Also $MY \perp CD$ and $NX \perp AB$ Prove

$$\frac{NX}{MY}=\frac{CD}{AB}$$

Solution by V. C. Bailey, Delaware, Ohio

Extend AB and DC to meet at E.
Triangles ECB, ENM and EDA are similar.
Also, triangles EXN and EYM are similar.
Then $DC/AB=CE/BE=NE/ME=NX/MY$
That is, $NX/MY=CD/AB$.

Solutions were also offered by Wm. A. Richards, Berwyn, Ill.; M. M. Dreiling, Collegeville, Ind.; Hazel S. Wilson, Annapolis, Md.; Helen M. Scott, Baltimore, Md.; Hyman Zalosh, New York City; M. Hopkins, Kankakee, Ill.; Agnes Rutherford, Syracuse, N. Y.; Walter R. Warne,



Columbia, Mo.; James Maltby, Holyoke, Mass.; Hugo Brandt, Chicago; Felix John, Philadelphia, Pa.; M. Kirk, Media, Pa.

1959. *Proposed by Pvt. Milton Schiffenbauer, Camp Wolters, Texas*

Find two points of intersection of the curves:

$$y^2-y(x^2+x)+x^3+1=0$$
$$2y-x^2-x=0.$$

Solution by M. M. Dreiling, Collegeville, Indiana

(1) $$y^2-(x^2+x)+x^3+1=0$$

(2) $$2y-x^2-x=0.$$

Substitute the value of y from (2) into (1) obtaining

$$x^4-2x^3+x^2-4=0,$$

or

$$(x+1)(x-2)(x^2-x+2)=0,$$

which yields the points $(-1, 0)$ and $(2, 3)$.

Solutions were also offered by Norman Anning, University of Michigan; Hyman Zalosh, New York City; M. Kirk, Media, Pa.; Helen M. Scott; Baltimore, Md.; Wm. A. Richards, Berwyn, Ill.; Hazel S. Wilson, Annapolis, Md.; V. C. Bailey, Delaware, Ohio; V. H. Paquet, Tigard, Ore.; A. W. Gordon, Chilton, Wis.; Felix John, Philadelphia, Pa.; Joseph Lerner, New York City; Hugo Brandt, Chicago; Walter F. Warne, Columbia, Mo. and the proposer.

1961. *Proposed by Brother Felix John, Philadelphia, Pa.*

Find a simple value for

$$\frac{(4+\sqrt{15})^{5/2}+(4-\sqrt{15})^{5/2}}{(6+\sqrt{35})^{5/2}-(6-\sqrt{35})^{5/2}}. \tag{1}$$

Solution by Frances L. Miksa, Aurora, Illinois

$$4+\sqrt{15}=\left[\frac{\sqrt{5}+\sqrt{3}}{\sqrt{2}}\right]^2 \tag{2}$$

$$6+\sqrt{35}=\left[\frac{\sqrt{7}+\sqrt{5}}{\sqrt{2}}\right]^2. \tag{3}$$

Inserting values of (2) and (3) in (1) it becomes

$$\frac{(\sqrt{5}+\sqrt{3})^6+(\sqrt{5}-\sqrt{3})^6}{(\sqrt{7}+\sqrt{5})^6-(\sqrt{7}-\sqrt{5})^6}. \tag{4}$$

Expanding, and simplifying expression (4) becomes:—

$$\frac{11}{31} \text{ ans.}$$

Other solutions were offered by Wm. A. Richards, Berwyn, Ill.; Felix John, Philadelphia, Pa.; Helen M. Scott, Baltimore, Md.; Hugo Brandt, Chicago; M. Kirk, Media, Pa.; M. Hopkins, Kankakee, Ill.; Norman Anning, University of Michigan; Hyman Zalosh, New York City; Bernard Lacombe, Montreal, Canada; Hazel S. Wilson, Annapolis, Md.

1962. *Proposed by Nellie Bishop, Seneca Falls, New York.*

In any plane triangle ABC prove that

$$\tan B=\frac{b \sin A}{c-b \cos A}.$$

Solution by William A. Richards, Berwyn, Illinois

From the law of sines

$$\frac{\sin B}{b}=\frac{\sin C}{c}=\frac{\sin (A+B)}{c} \tag{1}$$

or

$$\frac{\sin B}{b}=\frac{\sin A \cos B+\cos A \sin B}{c}. \tag{2}$$

Then

$$c \sin B=b \sin A \cos B+b \cos A \sin B. \tag{3}$$

Dividing (3) by $\cos B$, we have

$$\frac{c \sin B}{\cos B}=b \sin A+b \cos A \tan B \tag{4}$$

or

$$c \tan B-b \cos A \tan B=b \sin A. \tag{5}$$

Hence

$$\tan B=\frac{b \sin A}{c-b \cos A} \text{ Q.E.D.}$$

Solutions were also offered by V. C. Bailey, Delaware, Ohio; Hugo Brandt, Chicago; William M. Slaichert, Ames, Iowa; Hyman Zalosh, New York City; M. Kirk, Media, Pa.; Walter R. Warne, Columbia, Mo.; Hiram B. Waggoner, Gananoque, Canada; Brother Philip, Montreal, Canada; M. Hopkins, Kankakee, Ill.; Margaret Joseph, Milwaukee, Wis.; Bernard Lacombe, Montreal, Canada; A. J. Goodman, Helen M. Scott, Baltimore, Md.; Felix John, Philadelphia, Pa.; Norman Anning, University of Michigan; Joseph Lerner, New York City and the proposer.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

PROBLEMS FOR SOLUTION

1975. *Proposed by W. A. Wallace, St. Paul, Minn.*

If N is any odd integer, the square of any multiple of N is the sum of N consecutive integers.

1976. *Proposed by Mary Holden, Jennings, Mo.*

If four tangents to a circle determine a harmonic range on a fifth tangent, they determine a harmonic range on every other tangent.

1977. *Proposed by J. F. Arena, Boone, N. C.*

Find the derivative of $x \sin x$ with respect to $\tan x$.

1978. *Proposed by J. F. Arena, Boone, N. C.*

If x is a proper fraction show that

$$\frac{x}{1-x^3}-\frac{x^3}{1-x^6}+\frac{x^5}{1-x^{10}}-\cdots=\frac{x}{1+x^3}+\frac{x^3}{1+x^6}+\frac{x^5}{1+x^{10}}+\cdots.$$

1979. *Proposed by J. F. Arena, Boone, N. C.*

Find the value of the infinite product:

$$3^{1/3}\cdot 9^{1/9}\cdot 27^{1/27}\cdots.$$

1980. *Proposed by Brother Felix John, Philadelphia, Pa.*

In a shooting competition a man can score 5, 4, 3, 2, 0 points for each shot. Find the number of different ways in which he can score 30 in 7 shots

---

FROZEN FOOD LOCKERS

Students, returning servicemen, teachers, and others interested in the frozen food locker industry as an occupation will find helpful information in a six page leaflet entitled *Frozen Food Lockers* just published by Occupational Index, Inc., New York University, New York 3, N. Y. Single copies are 25¢, cash with order.

This is one of a series of 75 such leaflets describing opportunities in 75 different occupations. Each one covers the nature of the work, abilities and training required, earnings, entrance and advancement, and miscellaneous advantages and disadvantages.

Excessive humidity in polishing rooms and abrasive wheel drying rooms is the cause of a great deal of often unknown trouble with glue. The moisture in the air prevents the glue from setting and holding properly. Dehumidifying is the solution of this problem. Every polishing or wheel room should be equipped with a hygrometer by which the percentage of humidity in the air can be readily determined. Humidity of 60% at 37 to 53°F. is ideal, and 50% at 75 to 80°F. is good.

BOOKS AND PAMPHLETS RECEIVED

SOLID GEOMETRY, by Frank M. Morgan, *Director of Clark School (College Preparatory), Hanover, New Hampshire; Formerly Assistant Professor of Mathematics, Dartmouth College, Hanover, New Hampshire,* and W. E Breckenridge, *Formerly Head of the Department of Mathematics, Stuyvesant High School, New York City.* Revised Edition. Cloth. Pages viii+330+x. 13.5×19.5 cm. 1946. Houghton Mifflin Company, 2 Park Street, Boston. Mass. Price $1.48.

MATHEMATICS FOR TECHNICAL AND VOCATIONAL SCHOOLS, by Samuel Slade, B.S., C.E., *Machine and Metal Trades High School, New York City,* and Louis Margolis, A.B., C.E., *Head of Mathematics Department, Alexander Hamilton Vocational High School, Brooklyn, New York City.* Third Edition. Cloth. Pages vii+532. 12.5×19 cm. 1946. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $2.50.

WILEY TRIGONOMETRIC TABLES. Second Edition. Cloth. Pages v+117. 13.5×21.5 cm. 1945. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $1.00.

INTERNATIONAL PAYMENTS; A SCIENCE, by Ray Ovid Hall. Cloth. Pages xi+124. 21×28 cm. 1946. Ray Ovid Hall, 1763 Columbia Road, Washington 9, D. C. Price $4.00.

ALL AROUND US, by Wilbur L. Beauchamp, Gertrude Crampton, and William S. Gray, *Reading Director.* Grades Two and Three *Teachers' Edition.* Cloth. 80 pages. 20×26 cm. 1944. Scott, Foresman and Company, 623 S. Wabash Avenue, Chicago 5, Ill. Price $1.08.

HOW DO WE KNOW? by Wilbur L. Beauchamp, Gertrude Crampton, and William S. Gray, *Reading Director.* Grades Two and Three. Teachers' Edition. Cloth. 96 pages. 20×26 cm. 1945. Scott, Foresman and Company, 623 S. Wabash Avenue, Chicago 5, Ill. Price $1.24.

STUDENTS' GUIDE TO EFFICIENT STUDY, by Luella Cole, Ph.D., and Jessie Mary Ferguson, Ph.D., *Professor Emeritus, American University.* Third Edition. Paper. 70 pages. 15×23 cm. 1946. Rinehart and Company, Inc., 232 Madison Avenue, New York 16, N. Y. Price 50 cents.

THE ROLE OF MATHEMATICS IN CONSUMER EDUCATION. A Statement Prepared for The Consumer Education Study of the National Association of Secondary-School Principals by The Commission on Post-War Plans of The National Council of Teachers of Mathematics. Paper. 23 pages. 15.5 ×23.5 cm. 1945. The Consumer Education Study, 1201 Sixteenth Street, N. W., Washington 6, D. C. Single Copies free on request and additional copies 15 cents each.

THE DIMENSIONS OF AMERICAN BROADCASTING, by William C. Ackerman, *Director of Columbia's Reference Department of the Columbia Broadcasting System.* Paper. 18 pages. 15×23 cm.

BOOK REVIEWS

THE MILKY WAY, Second Edition, by Bart J. Bok and Priscilla F. Bok, *Harvard College Observatory*. Cloth. Pages vi+224. 14.5×21.5 cm. 1945. Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $2.50.

This is the second edition of one of the well-known Harvard Books on astronomy for the general reader edited by Harlow Shapley and Bart J. Bok. The changes throughout the book are rare but the diction of a few sentences has been improved, recent discoveries and better methods of observation are mentioned, important changes in the table of near stars are indicated, an arrow is added to figure 19 to point out the change discussed, a new graph is substituted on page 55, and the contributions of the Latin-American observers are recognized on page 146. Other minor improvements have been made but the greatest change is the addition of a "Postscript" of 20 pages giving the more important recent advances in the study of the Milky Way. Here the authors conclude from the study of new evidence that the previous estimate of 30,000 to 35,000 light years from the sun to the galactic center is correct and that the Milky Way extends at least 15,000 light years in the opposite direction. Recent work, however, indicates that the total mass is much less than previously stated. The discovery of "invisible" companions to many near-by stars shows that the sun is probably unique in this respect since the mass of its largest planet is only one thousandth the mass of the sun. The cosmic dust clouds is another of the interesting topics of recent investigation. Many other important questions are outlined for future study.

G. W. W.

PRACTICAL ANATOMY OF THE RABBIT, by the late Dr. B. A. Bensley, *formerly professor of Zoology in the University of Toronto*. Seventh edition revised and edited by Dr. E. Horne Craigie, *Associate Professor of Comparative Anatomy and Neurology in the University of Toronto*. Cloth. pages x+358, 14×20 cm. 112 illustrations. 1945. The Blakiston Co., 1012 Walnut Street, Philadelphia, Pennsylvania.

Originally edited by Dr. B. A. Bensley, this laboratory textbook was revised by him through the fifth edition. Since his death Dr. E. H. Craigie, his associate in the University of Toronto, has twice revised it. The present edition, the seventh, has had many parts rewritten, with alterations and additions here and there. Additions of entirely new sections on sense organs and the essential structure of the liver are included as well as 24 new illustrations and photographs. This brings the total to 112 besides 8 double-page plates of frozen sections of the rabbit fetus.

This volume, unlike many lab manuals, is a text as well as a guide for laboratory procedure. Besides the final section on the actual dissection, more than a third of the book is given over to a discussion of the histology and organ-systems of the rabbit. The middle section of about 50 pages is devoted to a very complete discussion of the osteology of the rabbit. The dissection is taken up by the regional plan, so that only a single specimen is necessary.

Several features of the book are worthy of mention. In the first place, the paper on which it is printed is of exceptional quality. The type is clear and the important terms are always put in bold-faced type. The unusual number of splendid illustrations add immeasurably to the value of the book. The directions for dissection are clearly given, usually in outline form so that one does not have to keep re-reading when referring back to the directions. Origin and insertion of muscles are especially clearly stated in each case.

The index is very complete, with the pages where illustrations occur in bold-faced type.

For those classes using the rabbit for mammalian dissection, this book leaves little to be desired.

HOWARD F. WRIGHT

COLLEGE ALGEBRA AND TRIGONOMETRY, A BASIC INTEGRATED COURSE, by Frederic H. Miller, *Professor of Mathematics, The Cooper Union School of Engineering*. Cloth. Pages xii+324. 13.5×21.5 cm. 1945. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $3.00.

This book is subtitled, *A Basic Integrated Course*, and is based on the premise (with which the reviewer finds himself in hearty agreement) that the study of college algebra and trigonometry are not ends in themselves, but are a preparation for the study of analytic geometry and the calculus and its applications

The author's choice of material and order of presentation have been influenced by his purpose:—to lay a suitable foundation for the study of more advanced mathematics. The first three chapters discuss number systems, the postulates of algebra, functions and graphs, general definitions of the trigonometric functions, and radian measure. The integration of the two subjects is begun in Chapter IV, on identities and conditional equations.

Throughout the book emphasis is placed on the analytical aspects of the subjects, and computational drill, such as the solution of triangles, is treated briefly. Noteworthy features of the text are: the early introduction of determinants; the very clear treatment of complex numbers; an introduction to the limit concept through infinite geometric progressions; a detailed consideration of inequalities, both algebraic and trigonometric; a discussion of functional variation as applied to both algebraic and trigonometric functions; and a treatment of exponential and logarithmic functions which facilitates the solution of transcendental equations.

This reviewer is of the opinion that the success with which he has taught Professor Miller's other texts would have been even more pronounced if students of calculus and partial differential equations had had the benefit of the type of preparation which this book provides.

H. S. POLLARD

ELECTRONIC EQUIPMENT AND ACCESSORIES, by R. C. Walker. Cloth. Pages vii+393. 13.5×22 cm. 1945. The Chemical Publishing Company, Inc., 234 King Street, Brooklyn 31, N. Y. Price $6.00.

Many excellent books have been written on the vacuum tube and its application to radio circuits but comparatively few have dealt with the use of the vacuum tube in industry. This book however offers specific information on various applications of electronic *devices*, its aim being to "present a simple introduction to the main sections of electronics to practical engineers, mechanics, students and other readers who at least have acquired the elements of electricity and magnetism but who are not specialists in the use or design of electronic apparatus." No advanced knowledge of mathematics is needed to understand this book.

The first chapter is a general review of the fundamentals of thermionic valves including a brief treatment of radio applications. In Chapter II the use of the valve as an amplifier of steady and low frequency voltages is taken up. Voltage amplification is distinguished from power amplification, the relay circuit, different methods of coupling stages, and the electrometer triode are discussed. The following chapter headings should

convey an idea of the remaining content of the book: Applications of Thermionic Valves, Gasfilled Valves, Applications of Gasfilled Triodes, Light-sensitive Devices, Typical Methods of Applying Light Cells, The Source of Light, The Cathode Ray Tube, Methods of Using Cathode Ray Tubes, Miscellaneous Electronic Devices, Small Switchgear, Delayed-Action Devices, Impulse Recording and Counting, and Miscellaneous Circuit Accessories.

To the student intending to specialize in electronic engineering this book should make a valuable addition to his technical library.

D. L. BARR
Senn High School, Chicago, Ill.

CAREERS FOR WOMEN IN BANKING AND FINANCE, by Dorcas Campbell, *An Officer of the East River Savings Bank in New York City and An Instructor in Business Administration at New York University*. Illustrated. Cloth. Pp. 260. 14.5×21 cm. 1944. E. P. Dutton and Company, Inc., New York. Price $2.75.

Careers for Women in Banking and Finance is a survey of jobs women now hold in banking. It includes expert opinion and advice on the future of women in business; the personnel situation in which bankers, businessmen, employment counselors, and potential and actual career women are all intensely interested.

The author discusses the findings of personnel clinics in fitting women to banking jobs, what personnel tests prove, the opinions on women in banking of secretaries of state banker's associations, forecasts on opportunities ahead by such experts as financial writers and economists, and reports from financial advertising agents and trade association executives.

Mathematics teachers of girls are likely to be much interested in recommending this book.

JOSEPH J. URBANCEK
Chicago Teachers College

CAREERS FOR GIRLS IN SCIENCE AND ENGINEERING, Evelyn Steele, *Director, Vocational Guidance Research Vocational Editor*, Scholastic, *the National High School Weekly*. Illustrated. Cloth. Pp. 190. 14.5×21 cm. 1943. F. P. Dutton and Company, Inc., New York. Price $2.50.

Evelyn Steele has outlined in this book a chart and guide for young women who seek post war careers in science and engineering. Most of the book is concerned with explorations of the many divisions of labor open to girl aspirants in the field, including physics, chemistry, geology, and biological sciences, electrical, aeronautical, chemical, mechanical, and civil engineering.

To get the material she conducted hundreds of interviews with officials and women workers in major American industrial firms, and held long consultations with directors of United States Government Bureaus.

Teachers of mathematics would doubtless welcome an opportunity to recommend this book to the girls in their classes. From the author's foreword, we quote:

"It is an understatement to say that women are wanted in science and engineering. They are desperately needed."

JOSEPH J. URBANCEK

Envy, like flame, blackens that which is above it, and which it cannot reach.—*J. Petit Senn.*